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ORIGINALS

Hydration practices of runners during training vs competition

Somatotype comparative study between spanish and brazilian young females dancers

Young women soccer players. Anthropometric and physiological characteristics. Evolution in a Sports season

Survey of safety requirements for swimming pools associated with accidents through the jurisprudence

REVIEWS

Evolution of injury prevention training monitoring

Effectiveness of eccentric exercise in patellar tendinopathy. Literary review



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- **Actividad Física Terapéutica** ⁽²⁾
 - **Alto Rendimiento Deportivo:**
Fuerza y Acondicionamiento Físico ⁽²⁾
 - **Performance Sport:**
Strength and Conditioning ⁽¹⁾
 - **Audiología** ⁽²⁾
 - **Balneoterapia e Hidroterapia** ⁽¹⁾
 - **Desarrollos Avanzados**
de Oncología Personalizada Multidisciplinar ⁽¹⁾
 - **Enfermería de Salud Laboral** ⁽²⁾
 - **Enfermería de Urgencias,**
Emergencias y Cuidados Especiales ⁽¹⁾
 - **Fisioterapia en el Deporte** ⁽¹⁾
 - **Geriatría y Gerontología:**
Atención a la dependencia ⁽²⁾
 - **Gestión y Planificación de Servicios Sanitarios** ⁽²⁾
 - **Gestión Integral del Riesgo Cardiovascular** ⁽²⁾
 - **Ingeniería Biomédica** ⁽¹⁾
 - **Investigación en Ciencias Sociosanitarias** ⁽²⁾
 - **Investigación en Educación Física y Salud** ⁽²⁾
 - **Neuro-Rehabilitación** ⁽¹⁾
 - **Nutrición Clínica** ⁽¹⁾
 - **Nutrición y Seguridad Alimentaria** ⁽²⁾
 - **Nutrición en la Actividad Física y Deporte** ⁽¹⁾
 - **Osteopatía y Terapia Manual** ⁽²⁾
 - **Patología Molecular Humana** ⁽²⁾
 - **Psicología General Sanitaria** ⁽¹⁾
- ⁽¹⁾ Presencial ⁽²⁾ Semipresencial

Evolution of injury prevention training monitoring

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Summary

Today, no one doubts the relationship between training loads and their influence on sports injuries. Object of study: literature review on training load and injury prevention in team sports that allow us to advance our knowledge of it.

It has made an electronic literature review in 2015 on the basis of Web of Science (WOS), Pubmed and Scopus. The search strategies and key words were "training load", "prevention injuries" and the combination by the term AND/& with control team sports. The "n" has been discussed "training load" (49) "prevention injuries & training load & Control & team sports" (16) "prevention injuries & training load" (204). 5 thematic blocks were obtained: Control and monitoring of training (13.6%), prevention of injuries (39.2%), prevention of anterior cruciate ligament (15.2%), injury incidence (18.4%) and others (13.6%).

The load control should collect quantitative and qualitative data from the training and the rest of the day. The general and specific strength training, with particular attention to eccentric work, proprioceptive, neuromuscular control and coordination form the pillars on which a plan for injury prevention is based. Continuous review of rules of the game and the protective material should be considered because it may allow to reduce the incidence of injury. It should continue with biomechanical studies and video to enable further progress in understanding the causes and factors of injuries. Epidemiological studies are needed about the incidence of injury in the general population to give us the magnitude of the problem. Further work is needed to promote the prevention of injury from the global perspective of the athlete from childhood.

Key words:

Load. Training.
Prevention. Injuries.
Team sports.

Evolución de la prevención de lesiones en el control del entrenamiento

Resumen

En la actualidad, nadie duda de la interrelación entre las cargas de entrenamiento y su influencia en las lesiones deportivas. Objeto de estudio: realizar una revisión bibliográfica sobre el control del entrenamiento y la prevención de lesiones en los deportes colectivos que nos permitan avanzar en el conocimiento del mismo.

Se ha realizado una revisión bibliográfica electrónica en el año 2015 en las bases de datos *Web of Science* (WOS), Pubmed y Scopus. Las estrategias de búsqueda y palabras clave fueron "training load", "prevention injuries" y la combinación mediante el término AND/& con control, team sports. La "n" analizada ha sido "training load" (49), "prevention injuries & training load & control & team sports" (16), "prevention injuries & training load" (204). De la revisión se obtuvieron 5 bloques temáticos: control y monitorización del entrenamiento (13,6%), prevención de lesiones (39,2%), prevención del ligamento cruzado anterior (15,2%), incidencia lesional (18,4%) y otros (13,6%).

El control de la carga debe recoger datos cuantitativos y cualitativos tanto del entrenamiento como fuera del mismo. Los trabajos de fuerza general y específica, con especial atención al trabajo excéntrico, control propioceptivo y la coordinación neuromuscular conforman los pilares en los que se sustenta un plan de prevención de lesiones. Debe tenerse en cuenta la revisión continua tanto de las reglas del juego como del material de protección ya que puede permitir disminuir la incidencia lesional. Se deben seguir realizando estudios biomecánicos y de vídeo que permitan seguir avanzando en el conocimiento de las causas y factores de las lesiones. Es necesario estudios epidemiológicos de la incidencia lesional en la población en general que nos den la magnitud del problema. Es necesario seguir trabajando en fomentar la prevención de lesiones desde la perspectiva global del deportista desde la infancia.

Palabras clave:

Carga. Entrenamiento.
Prevención. Lesiones.
Deportes de equipo.

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Introduction

In the second half of the 20th century, sport gained significant importance, so much so that different modalities have gradually become professionalised, and an increasing amount of people take part, thus increasing the occurrence of injury (OI). Knowledge regarding training has shifted from a fundamentally empirical-based “trial and error” system, to one which calls for the application of scientific methods, and the monitoring and recording of training loads and the OI, as well as an analysis of a possible link between the two.

Over the past two decades, objectives have evolved. According to Platonov (1993)¹ the main aim was to optimise the preparation process and competitive activity, in accordance with the objective assessment of the different aspects of maturity and the functional possibilities of the body’s most important systems. For Viru and Viru (2003)² the aim was to obtain information about the real effects of the session to discover the type of work that is most suited to each athlete. García *et al.* (2010)³ take that even further and establish that the aim is to implement adaptations and corrections to the training in a much more specific way, customising the training session, improving the process and obtaining the best results possible from each athlete, whilst minimising the risk of injury.

If the athlete for whatever reason, whether physical, psychic or emotional, is not alright, performance will be affected. This change from understanding variables in an isolated way to interlinking them, brings us to the holistic theories in which neither the training or the athlete can be understood without taking into account everything that is occurring in the process and around the individual in question (Figure 1).

The objective of training shifts from trying to achieve the peak state of fitness without truly considering the possible consequences, to attaining the best possible state of fitness at all times and minimising the risk of injury. Of course, for this concept the sport in question must be considered, as well as the characteristics of competition.

Antecedents

Controlling the training load

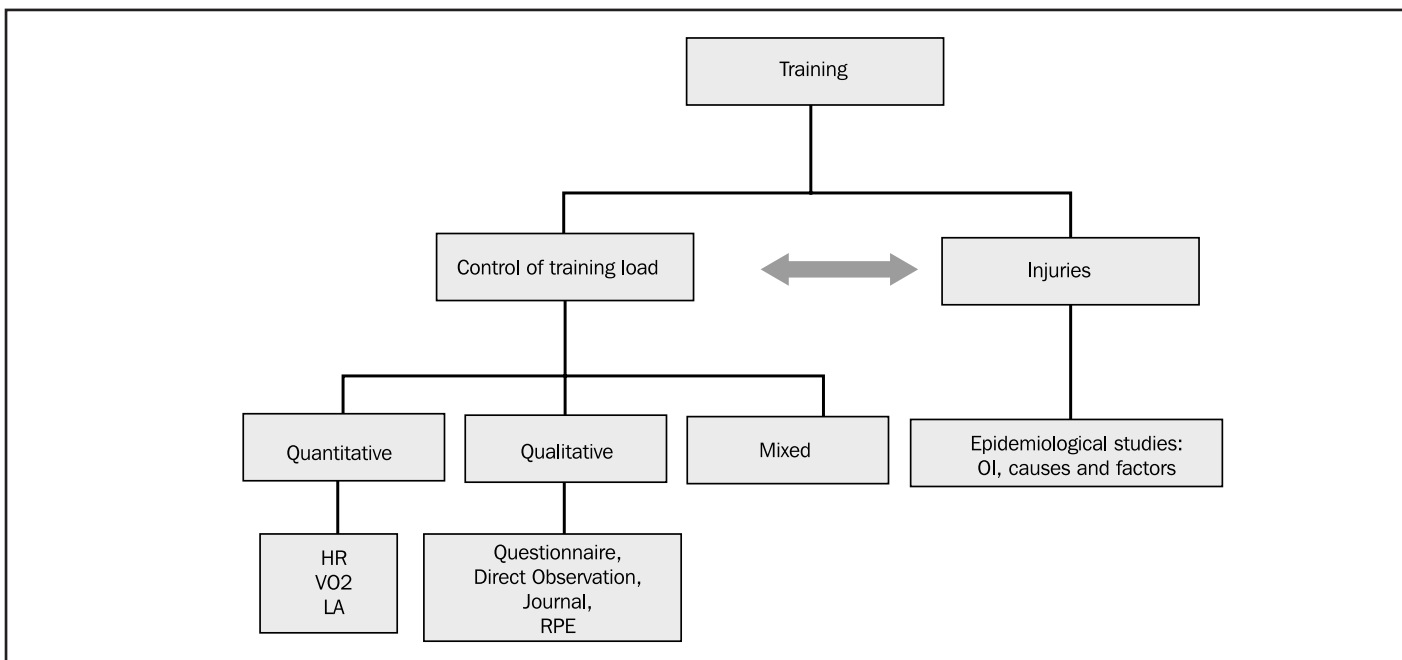
Controlling the physical factor has mainly focused on the study of the internal training load with regards to physiological parameters such as heart-rate (HR)⁴⁻¹³, oxygen consumption (VO2)¹⁴⁻²³ and blood lactate (LA)²⁴⁻³⁰, as objective and quantitative measures.

In recent years, some authors³¹⁻³³ take the psychological factor into account based on the elaboration of neuromuscular information and strategic factors that involve the training load applied to the player. They are considered *qualitative* methods, and in daily practice they are presented as an effective way of discovering how planned training loads affect the players³⁴. Some of these control methods are training logs^{34,35}, questionnaires^{36,37}, direct observation^{38,39} and the rating of perceived exertion.

Rating of Perceived Exertion

Borg is considered to be the benchmark for “Rating of Perceived Exertion” (RPE) studies in the physiology of exercise, both for being the pioneer in this field as well as for being the most cited⁴⁰⁻⁴⁴.

Figure 1. Interlinked analysis of the training process.



HR: Heart rate; VO2: Oxygen consumption; LA: Lactate; RPE: Rating of Perceived Exertion

Borg's RPE Scales from 1962⁴⁰ and 1982⁴² have been used in numerous studies to control and evaluate exertion made, both in team sports⁴⁵⁻⁴⁸ as well as individual sports⁴⁹.

Already in the design of the RPE Scale (Borg, 1962)⁴⁰, the author established that to perform a more complete assessment, use of a "double scale" was necessary, based on the athlete's perception and the foresight of the technical team, allowing for the difference in the training load assessment from each part to be established numerically. The results from different studies in athletics⁵⁰, swimming⁵¹, basketball⁵² and handball⁵³ have concluded that the double scale reveals how the player is dealing with the training load with regards to the amount planned, making it possible to adjust the plan in accordance with the information received immediately, thus reducing the risk of injury.

The correlations obtained from studies between the RPE method and other means of quantifying the internal training load in team sports have been very high, as demonstrated in studies that compare the RPE methods and HR⁵⁴⁻⁵⁸, RPE and VO₂⁵⁹⁻⁶¹ and RPE and LA⁶²⁻⁶⁵.

Preventing injury

The body is not designed for some actions and movements, resulting in injuries in sporting practice, which can be one of the worst health consequences for the athlete. An injured player means zero performance within the team, as the player cannot compete, or at least not in optimum conditions⁶⁶.

Currently, no-one questions the relationship between training loads and their influence on sporting injuries. Increased training, accumulated fatigue, a mismatch between the prescribed and perceived training load, may result in a considerable increase in sporting injuries.

Injury and performance are two words that should be mutually exclusive. However, the words injury, training, planning and control should be intrinsically related, though it has not always been this way.

At this stage we propose the necessity to revalue the prevention of injuries. Why discuss prevention? Preventive strategies are justified for both medical and financial reasons⁶⁶. Injuries among elite athletes imply a high sporting and financial cost. In the English professional league a loss of 74.7 million pounds was estimated from injuries acquired during the monitoring of two seasons⁶⁷.

When it comes to planning the training process, prevention has transformed from being considered an implicit aspect within the programme to having its own fundamental position around which everything else is based. An injured player is not operational, and thus is not useful in competition.

Today, the group responsible for establishing injury prevention strategies: medical team, physical trainers and coaches have to participate in continuous training to allow them to identify the individuals prone to injury and preventive programmes to ensure the risk of injury is as low as possible.

Collecting injury data

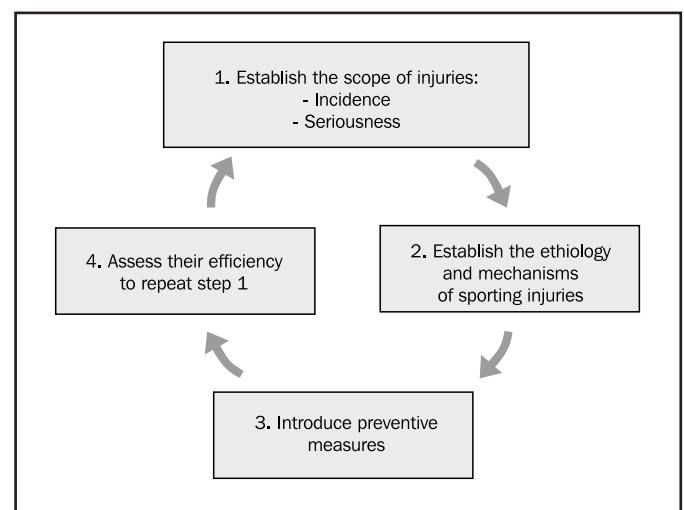
Before initiating a sporting injury prevention measure or programme, first their magnitude must be defined. Secondly, the mechanisms

and factors that intervene in their occurrence must be identified. Finally, measures that may reduce the OI risk should be established and their efficiency assessed (Figure 2).

Various epidemiological studies have examined the OI, causes and factors in different sports. It should always be noted that comparisons between studies become complicated unless the same data collection methodology has been used in the process^{68,69}. Methodological consensus must be attained, such as the Injury Consensus Group via the International Federation of the Football Association Medical Assessment and Research Centre (F-MARC)⁷⁰, defining each variable specifically and thus enabling the comparison of results with other studies that employ the same methodology^{71,72}. In the review carried out by Parkkari *et al.* (2001)⁶⁸ a sequence is suggested for collecting injury data, establishing the most important points to consider:

- Clearly define what constitutes an injury and standardise it.
- Type of sporting event and the activity being undertaken at the time of injury.
- Sporting level (recreational vs. competitive).
- Location where the injury took place.
- Mechanism of the injury, acute or through overuse.
- Level of supervision.
- Nature of the injury (severe sprain, fracture, etc.).
- Part(s) of the body injured.
- The seriousness of the injury (affected activity, working time lost, treatment needs, treatment costs, permanent damage, deterioration or disability).
- The characteristics of the injured person.
- Treatment needed (duration and nature).
- The use of protective equipment.
- Adherence to the game rules (foul play and injuries).
- Cost of the injury (direct, indirect).
- Display data should be established (population at risk and display time).

Figure 2. Sporting injury prevention sequence^{68,69}.



- Calculate simplicity (vs. training the data collection personnel) and the time needed (is it realistic?) for collecting data.
- Recognise the limitations or error sources (also when giving results).

The study objective of this work is to perform a bibliographical review of the control of training and the prevention of injuries in team sports, which will allow us to make progress in the understanding of this particular field.

Method

An electronic bibliographic review was performed in 2015 by the authors of this article. The methodological quality of the studies was not assessed, given that the review only considered works published on well-known and prestigious databases: Web of Science (WOS), Pubmed and Scopus, thus the quality indicator was considered sufficient. Search strategies and key words established were "training load", "prevention injuries" and their combinations using the term AND/& with "control", "team sports". All the articles selected were exported onto the Endnote programme to facilitate their classification by contents.

A meta-analysis was not applied to this review. It was a systematic review with the main aim of producing a summary of the most relevant studies undertaken in the target matter, determining the following steps: operative definition of the research issue; procedures for searching for the literature; precise definition of the selection criteria of the studies; and codification of the information taken from the studies. To do this, the numerous perspectives associated with traditional reviews had to be reduced down, clarifying all the decisions and procedures applied in the selection, critical assessment and synthesis of the relevant studies in this field. No specific data was extracted from any of the studies reviewed in

this study, as our main interest was to establish the themes addressed by the scientific studies, as opposed to analysing their results.

Three specific search strategies were followed:

Training load

The following results were obtained from the searches carried out regarding training loads:

- Training load / Filtered to the "sport sciences" area: 36860/6298 (WOS); 7777 (Pubmed); 12795 (Scopus).
- Training load & control / Filtered to the "sport sciences" area: 11252/1390 (WOS); 1992 (Pubmed); 3338 (Scopus).
- Training load & team sports / Filtered to the "sport sciences" area: 257/221 (WOS); 20 (Pubmed); 249 (Scopus).
- Training load & control & team sports / Filtered to the "sport sciences" area: 59/49 (WOS); 14 (Pubmed); 33 (Scopus).

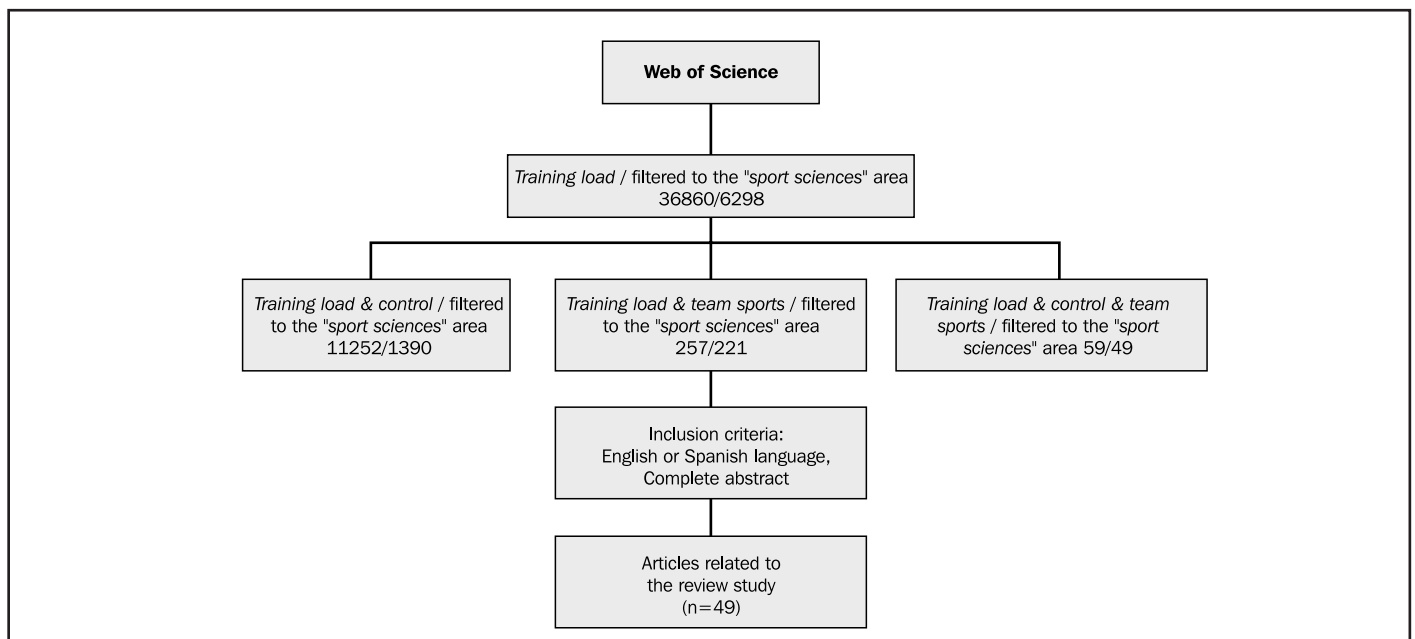
The WOS search was chosen as it produced the greatest number of results upon introducing the words "Training load & control & team sports" and filtered to the "sport sciences" area with n=49. Inclusion criteria were: English or Spanish language, access to complete abstract (Figure 3).

Prevention of injuries

The following results were obtained from the searches carried out for prevention of injuries:

- Prevention injuries/Filtered to the "sport sciences" area: 152035/14376 (WOS); 96929 (Pubmed); 66574 (Scopus).
- Prevention injuries & control /Filtered to the "sport sciences" area: 106565/7894 (WOS); 84138 (Pubmed); 13120 (Scopus).

Figure 3. Flow chart of the selection process of reviewed articles. Training load.



- Prevention injuries & team sports /Filtered to the “*sport sciences*” area: 737/645 (WOS); 499 (Pubmed); 583 (Scopus).
- Prevention injuries & control & team sports /Filtered to the “*sport sciences*” area: 424/400 (WOS); 352 (Pubmed); 95 (Scopus).

Due to the high number of results produced, this search was not used to analyse the study, rather the decision was taken to move on to the combination of key research words.

Training load & Prevention injuries

The following results were obtained from the searches carried out regarding the combination of training load and prevention of injuries:

- Prevention injuries & training load /Filtered to the “*sport sciences*” area: 353/204 (WOS); 145 (Pubmed); 172 (Scopus).
- Prevention injuries & training load & control /Filtered to the “*sport sciences*” area: 232/136 (WOS); 116 (Pubmed); 44 (Scopus).
- Prevention injuries & training load & team sports /Filtered to the “*sport sciences*” area: 23/21 (WOS); 5 (Pubmed); 14 (Scopus).
- Prevention injuries & training load & control & team sports / Filtered to the “*sport sciences*” area: 17/16 (WOS); 4 (Pubmed); 3 (Scopus).

The WOS search was selected due to the greater number of results produced. First, the search results were related to all the Prevention injuries & training load & control & team sport/Filtered to the “*sport sciences*” area producing n=16. Upon reviewing the articles and observing that they were all included within the previous review “*Training load & control & team sports*” n=49, the search made in WOS with the words “*Prevention*

injuries & training load” and filtered to the “*sport sciences*” area AND was chosen, producing n=204.

With the aim of focusing on prevention, the inclusion criteria were established as: English or Spanish language, complete article, and discussing prevention in sport, rejecting any that made reference to epidemiological studies. The sample was thus narrowed down to n=76 (59 original articles and 17 revised) (Figure 4).

Results

The results obtained from the reviews undertaken “*Training load & control & team sports*” and “*Prevention injuries & training load*” were classified by contents (Table 1).

The review grouped the articles into 5 themed blocks:

1. Control, training monitoring with 13.6%.
2. Prevention of injuries with 39.2%. It was deemed appropriate to divide this into:
 - Training measures with 31.2%. This included everything related to general strength work, physical control (core), balance, proprioception, neuromuscular, eccentric work and warming up (FIFA programme).
 - Other measures 8%.
3. Prevention of anterior cruciate ligament with 15.2%.
4. Injury frequency. Epidemiology with 18.4%.
5. Others with 13.6% which after being reviewed were rejected as they did not make reference to the study objective.

Figure 4. Flow chart of the selection process of the reviewed articles. Training load-control-prevention injuries-team sports.

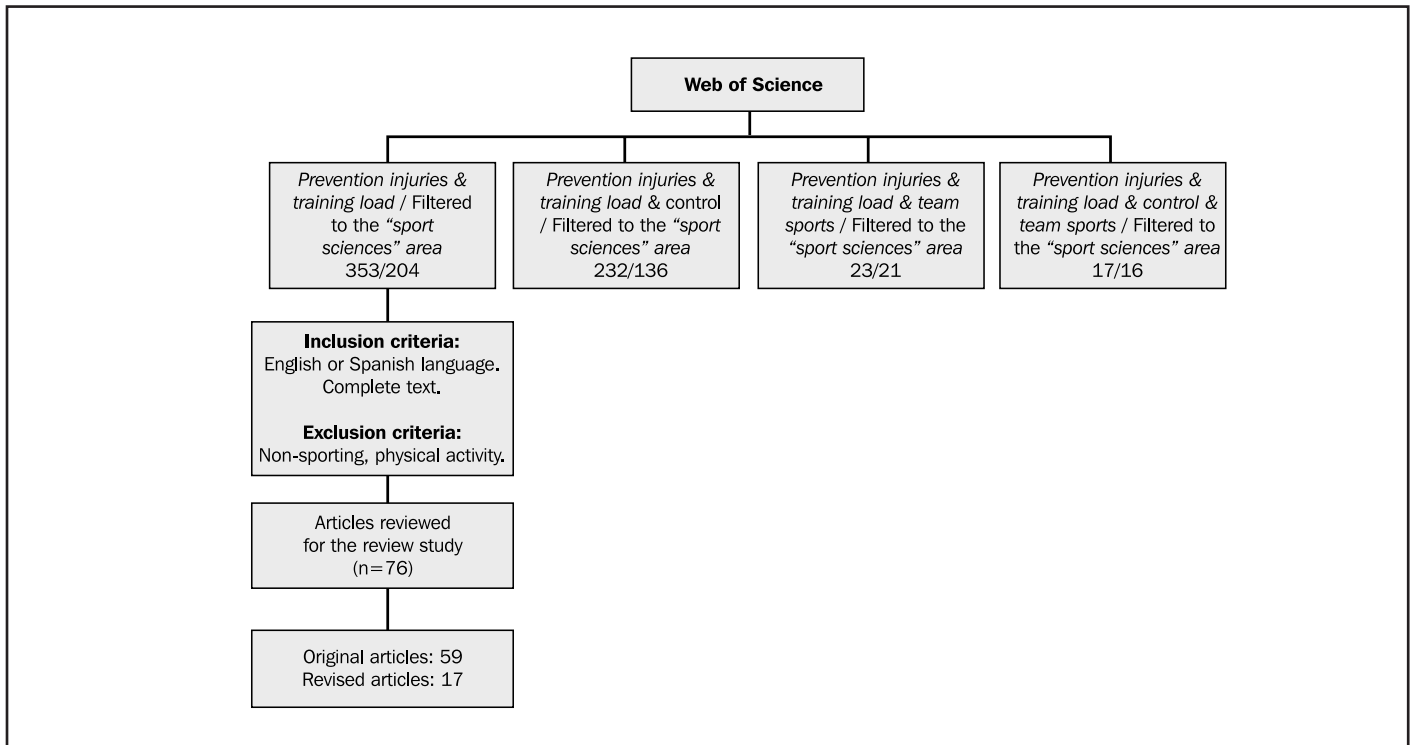


Table 1. Results of the bibliographic reviews classified by subject.

	Training load & control & team sports	Prevention injuries & training load	Total	%
Control, training monitoring	15	2	17	13.6
Prevention of injuries				
<i>Measures in the training</i>				
General strength	0	6	6	4.8
Physical control. Core.	3	2	5	4.0
Balance. Proprioception. Neuromuscular	2	16	18	14.4
Eccentric work	0	4	4	3.2
Warming up (FIFA programmes)	0	6	6	4.8
			39	31.2
<i>Other measures</i>				
Blood test- Supplementing	2	0	2	1.6
Biomechanical analysis	1	1	2	1.6
Rules and subject matter	0	3	3	2.4
Public Health	0	1	1	0.8
Educational Intervention	0	2	2	1.6
			10	8.0
Prevention of ACL	9	10	19	15.2
Injury frequency. Epidemiology	13	10	23	18.4
Others	4	13	17	13.6
N	49	76	125	100

Discussion

We are going to focus on the first three blocks, leaving the fourth (injury frequency) unanalysed, as they constitute epidemiological studies that discuss the magnitude of the problem and do not refer to any specific objective within the control study of training load and prevention of injuries.

Table 2 shows the studies found about Control, discusses monitoring training.

As we have seen in the introduction, currently, the monitoring and control of training loads has shifted from the control of external and internal loads, registering variables such as HR, RPE, TRIMPS, monotony and fatigue indices^{74,75,80-84,87}, to the use of the double scale (RPE of the player and the technical team) to establish whether or not there are deviations between the foreseen training load and that carried out⁷⁷, to the use of new technology, such as GPS which allows the distance covered and speed to be measured, establishing that from accumulated periods at high speeds, the injury rate increases up to 2.7⁸⁴, and other applications to standardise data collection from training loads and injuries such as the "Training and Injury Prevention Platform for Sports" (TIPPS)^{78,80}.

The holistic approach⁸⁸ requires a control not only of training loads from the perspective of training itself, but also the perspective of resting times. The athlete and the training are considered to be a complete unit from which peak performance can be expected^{79,86}.

The importance of optimising and controlling recovery becomes vital. Effective recovery by elite athletes following intense training can determine their success or failure. Ways of controlling these variables have been explored, by monitoring hours of sleep, rest, recovery⁸⁹ and stress using questionnaires such as RESTQ-Sport⁷⁶ or "Profile mood states" (POMS)⁸⁵ among others.

The training programme should be based on a certain volume and intensity to ensure that players can maintain their fitness level, perfect their game skills, internalise psychological qualities and carefully look after their health⁹⁰, avoiding acquiring an injury requiring a compulsory break from the sport. All this with the aim of controlling the variables that favour the monitoring of training, preventing overtraining, and therefore preventing injuries.

General strength programmes

A generic base of strength is essential for increasing sporting performance and for reducing the risk of injuries.

The articles reviewed are experimental studies in which over a period of time a certain type of training is implemented with or without a control group. In almost all cases the conclusions establish that the risk of injury reduces considerably^{68,69,99}, even if some suggest that a general strength programme alone is not enough to reduce the OI^{97,98}, requiring the application of other measures such as retraining movement and giving suitable feedback⁹⁶.

Table 2. Control, training monitoring.

Authors, Journal & Reference	Year	Article	Objective / Hypothesis
Training load & control & team sports (n=15)			
(74) Henderson, Brendan.; Cook, Jill.; Kidgell, Dawson J. <i>Journal of sports science and medicine</i> 14(3):494-500	2015	Game and training load differences in elite junior Australian football	Assess the differences in the measurements of external and internal physical training loads during competition and training (Australian football)
(75) Gallo, Tania.; Cormack, Stuart.; Gabbett, Tim. <i>Journal of sports sciences</i> 33(5):467-75	2015	Characteristics impacting on session rating of perceived exertion training load in Australian footballers	Establish the relationship between the training load and external qualification session of perceived exertion (Australian football)
(76) Matos, Felipe de Oliveira.; Samulski, Dietmar Martin.; Perroux de Lima, Jorge Roberto. <i>Revista brasileira de medicina do esporte</i> 20(5):388-93	2014	High loads of training affect cognitive functions in soccer players	Explore the behaviour of the psychological and physiological variables, the indicators of possible states of stress and recovery, and use these as markers to avoid the loss of performance and over-training (Football)
(77) Rodriguez-Marroyo, Jose A.; Medina, Javier; Garcia-Lopez, Juan. <i>Journal of strength and conditioning research</i> 28(69):1588-94	2014	Correspondence between training load executed by volleyball players and the one observed by coaches	Compare the training load executed by players with that observed by trainers (Volleyball)
(78) Lion, Alexis.; Theisen, Daniel.; Windal, Thierry. <i>Bulletin de la societe des sciences medicales du grand-duche de luxembourg</i> (3):43-55	2014	Moderate to severe injuries in football: a one-year prospective study of twenty-four female and male amateur teams	Assess the seriousness of injuries produced during a season among amateur teams (Football)
(79) Binnie, Martyn John.; Dawson, Brian.; Arnot, Mark Alexander. <i>Journal of sports sciences</i> 32(11):1001-12	2014	Effect of sand versus grass training surfaces during an 8-week pre-season conditioning programme in team sport athletes Effect of sand versus grass training surfaces during an 8-week pre-season conditioning programme in team sport athletes	Compare the intensity of training on two different surfaces: grass and sand
(80) Malisoux, Laurent.; Frisch, Anne.; Urhausen, Axel. <i>Journal of science and medicine in sport</i> 16(6):504-8	2013	Monitoring of sport participation and injury risk in young athletes	Compare the characteristics of sporting participation in the different categories of sports for young people and establish their relationship with injuries incurred
(81) Scott, Tannath J.; Black, Cameron R.; Quinn, John. <i>Journal of strength and conditioning research</i> 27(1):270-6	2013	Validity and reliability of the session-rpe method for quantifying training In Australian football: a comparison of the cr10 and cr100 scales	Validate the CR10 and CR100 perceived exertion scale in team sports that require highly intense intermittent exertion
(82) Miloski, Bernardo.; Freitas, Victor Hugo.; Bara Filho, Maurício Gattás <i>Revista brasileira de cineantropometria & desempenho humano</i> 14(6):671-9	2012	Monitoring of the internal training load in futsal players over a season	Analyse the internal training load in a macro-cycle, using the qualification method of perceived exertion of the session (Indoor football)
(83) Boullosa, Daniel Alexandre.; Abreu, Laurinda.; Luis Tuimil, Jose. <i>European journal of applied physiology</i> 112(6):2233-42	2012	Impact of a soccer match on the cardiac autonomic control of referees	Assess the heart-rate of adult referees during competition (Football)
(84) Gabbett, Tim J.; Ullah, Shahid. <i>Journal of strength and conditioning research</i> 26(4):953-60	2012	Relationship between running loads and soft-tissue injury in elite team sport athletes	Relate low and high intensity activities and high, and the risk of incurring soft-tissue injuries (Team sports)
(85) Lovell, G. P.; Townrow, J.; Thatcher, R. <i>Biology of sport</i> 27(2):83-8	2010	Mood states of soccer players in the English leagues: reflections of an increasing workload	Evaluate the mood of players in relation with the demands of competition and relate it with their health and performance (Football)
(86) Pyne, David B.; Mujika, Inigo; Reilly, Thomas. <i>Journal of sports sciences</i> 27(3):195-202	2009	Peaking for optimal performance: research limitations and future directions	REVIEW Establish the research constraints that aim to obtain peak performance in team sports

(keep going)

(87)	Merati, G.; Ce, E.; Maggioni, M. A. <i>Medicina dello sport</i> 59(3):325-33	2006	Cardio-pulmonary evaluation of mentally disabled soccer players	Assess the heart-rate and pulmonary response of people with mental disabilities (Football)
(88)	Impellizzeri, F.M.; Rampinini, E.; Coutts, A.J. <i>Medicine and science in sports and exercise</i> 36 (6):1042-7	2004	Use of RPE based training load in soccer	Apply the method based on RPE to quantify the internal training load (RPE of the session) and evaluate the correlations with other physiological methods (Football)
Prevention injuries & training load (n=2)				
(80)	Malisoux, Laurent.; Frisch, Anne; Urhausen, Axel. <i>Journal of science and medicine in sport</i> 16(6):504-8	2013	Monitoring of sport participation and injury risk in young athletes	Compare the characteristics of sports participation among the different categories of sports for young people and determine their relationship with injuries obtained.
(89)	Kellmann, M. <i>Scand J Med Sci Sports</i> 20(2):95-102	2010	Preventing overtraining in athletes in high-intensity sports and stress/recovery monitoring	REVIEW Review the methods used to prevent over-training among high-intensity athletes

Table 3. Prevention of injuries. Training measures.

Authors, Journal & Reference	Year	Article	Objective / Hypothesis	
Training load & control & team sports (n=5)				
Physical control. Core				
(91)	Ezechieli, M.; Siebert, C. H.; Ettinger, M. <i>Technology and health care</i> 21(4):379-86	2013	Muscle strength of the lumbar spine in different sports	Assess the capacity of stabilising the core in dynamic movements and the ability to absorb strength during repetitive training loads (Sports)
(92)	Jamison, Steve T.; Mcneilan, Ryan J.; Young, Gregory S. <i>Medicine and science in sports and exercise</i> 44(10):1924-34	2012	Randomized controlled trial of the effects of a trunk stabilization program on trunk control and knee loading	Determine the extent to which a quasi-static trunk stabilising training programme improves the core performance measures, leg strength, agility and the dynamic knee loading when compared to a resistance training programme.
(93)	Myer, G. D.; Brent, J. L.; Ford, K. R. <i>British journal of sports medicine</i> 42(7):614-9	2008	A pilot study to determine the effect of trunk and hip focused neuromuscular training on hip and knee isokinetic strength	Assess the neuromuscular training effect of the core in hip and knee strength
Balance. Proprioception. Neuromuscular				
(94)	Renkawitz, T.; Boluki, D.; Linhardt, O.; Grifka, J. <i>Sportverletzung-sportschaden</i> 21(1):23-8	2007	Neuromuscular imbalances of the lower back in tennis players - the effects of a back exercise program	Establish the risk of injury in athletes with neuromuscular imbalances of the back and set up a corrective programme (Tennis players)
(95)	Grindstaff, T.L.; Hammill, R.R.; Tuzson, A.E.; Hertel, J. <i>Journal of athletic training</i> 41(4):450-6	2006	Neuromuscular control training programs and noncontact anterior cruciate ligament injury rates in female athletes: a numbers-needed-to-treat analysis	META ANALYSIS Assess the related risk reduction associated with neuromuscular training programmes aimed at preventing non-contact anterior cruciate ligament injuries among female athletes
Prevention injuries & training load (n=34)				
General strength				
(96)	Herman, D.C.; Oñate, J.A.; Weinhold, P.S.; Guskiewicz, K.M.; Garrett, W.W.; Yu, B.; Padua, D.A. <i>American Journal of Sports Medicine</i> 37(7):1301-8	2009	The Effects of Feedback With and Without Strength Training on Lower Extremity Biomechanics	Hypothesis: By using the strength training of the lower extremities, there is a low capacity of altering the biomechanics of the knees and hips when landing after a jump
(97)	Herman, D.C.; Weinhold, P.S.; Guskiewicz, K.M.; Garrett, W.E.; Yu, B.; Padua, D.A. <i>American Journal of Sports Medicine</i> 36(4):734-40	2008	The Effects of Strength Training on the Lower Extremity Biomechanics of Female Recreational Athletes During a Stop-Jump Task	Hypothesis: By using the strength training of the lower extremities, there is an alteration to the biomechanics of the knees and hips when jumping, increasing the risk of injury

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(98)	Brushoj, C.; Larsen, K.; Nielsen, M.B.; Loye, F.; Holmich, P. <i>American Journal of sports medicine</i> 36(4):663-70	2008	Prevention of overuse injuries by a concurrent exercise program in subjects exposed to an increase in training load - A randomized controlled trial of 1020 army recruits	Hypothesis: A preventive training programme based on the literary review of the intrinsic risk factors, and undertaken alongside an increase in physical activity, may reduce the occurrence of knee injuries through overuse and medial tibia stress syndrome
(99)	Brooks, M.A.; Schiff, M.A.; Koepsell, T.D.; Rivara, F.P. <i>Medicine & science in sports & exercise</i>	2007	Prevalence of Preseason Conditioning among High School Athletes in Two Spring Sports	Establish the prevalence and indicators of training during the preseason among high school athletes.
(69)	Bahr, R.; Krosshaug, T. <i>Br J Sports Med</i> 39:324-9	2005	Understanding injury mechanisms: a key component of preventing injuries in sport	REVIEW Examine the current models being used to describe the etiology of sports injuries and develop a more comprehensive focus to understand the causes of injuries
(68)	Parkkari, J.; Kujala, U.M.; Kannus, P. <i>Sports Med</i> 31(14):985-95	2001	Is it Possible to Prevent Sports Injuries? Review of Controlled Clinical Trials and Recommendations for Future Work	REVIEW Review the trials on preventing injuries and describe their most important aspects relating to injury, monitoring and successful injury prevention
Physical control. Core				
(100)	Wilkerson, J.B.; Giles, J.L.; Seibel, D.K. <i>Journal of athletic training</i> 47(3):264-72	2012	Prediction of core and lower extremity strains and sprains in collegiate football players: a preliminary study	Assess the value of strength and core stability measurements as injury indicators in lower extremities and strains in adolescent players (Football)
(101)	Childs, J.D.; Teyhen, D.S.; Benedict, T.M.; Morris, J.B.; Fortenberry, A.D.; Mcqueen, R.M.; Preston, J.B.; Wright, J.C.; Dugan, J.I.; George, S.Z. <i>Medicine & science in sports & exercise</i>	2009	Effects of sit-up training versus core stabilization exercises on sit-up performance	Establish if undertaking core stability exercises instead of sit-ups during training has damaging effects on "sit-up" exercise performance
Balance. Proprioception. Neuromuscular				
(102)	Lindblon, H.; Waldén, M.; Carlford, S.; Häggglund, M. <i>British journal of sports medicine</i> 19(48):1425-30	2014	Implementation of a neuromuscular training programme in female adolescent football: 3- year follow-up study after a randomized controlled trial	Assess the implementation of a neuromuscular programme among female adolescent players after 3 years using a random controlled trial (Football)
(103)	Blackburn, J.T.; Norcross, M.F. <i>Journal of electromyography and kinesiology</i> 24:98-103	2014	The effects of isometric and isotonic training on hamstring stiffness And anterior cruciate ligament loading mechanisms	REVIEW Assess the effects of isometric and isotonic training on hamstring stiffness and anterior cruciate ligament injury mechanisms
(104)	Ostojic, M.; Vujkov, S.; Purkovic, S.; Trivic, T.; Stojanovic, M. <i>Archives of budo-science of martial arts</i> 7(2):61-4	2011	Physiological adaptations of a specific muscle-imbalance reduction training programme in the elite female judokas	Determine if isokinetic exercise can provide useful information about the strength of specific muscle groups and detect the imbalance among the muscle groups in Judo
(105)	González, G.; Oyarzo, C.; Fischer, M.; De la Fuente, M.J.; Diaz, V. y Berral, F.J. <i>Rev int med cienc act fis deporte</i> 11(41):95-114	2011	Specific postural balance training among young football players	Assess the training response of postural control among athletes without pathologies, using specific training.
(106)	Filipa, A.; Byrnes, R.; Paterno, M.V.; Myer, G.D.; Hewett, T.E. <i>Orthop sports phys ther</i> 40(9):551-8	2010	Neuromuscular training improves performance on the star excursion balance test in young female athletes	Establish if a neuromuscular training programme focusing on the core, stability and strength in the lower extremities can affect performance in the "Star Excursion Balance Test" (SEBT)
(107)	Roopchand-Martin, S.; Lue-Chin, S. <i>West indian med j</i> 59(2):182	2010	Plyometric training improves power and agility in jamaica's national netball team	Investigate the effects of a plyometric training programme over three weeks in improving jumping and agility and in reducing the number of injuries (Netball)
(108)	Barber-Westin, S.E.; Hermeto, A.A.; Noyes, F.R. <i>Journal of strength and conditioning research</i> 24(9):2372-82	2010	A six-week neuromuscular training program for competitive junior tennis players	Assess the efficiency of a specific training programme in improving neuromuscular rates during competition (Tennis)

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(109)	Emery, C.A.; Meeuwisse, W.H. <i>British journal of sports medicine</i> 44(8):555-62	2010	The effectiveness of a neuromuscular prevention strategy to reduce injuries in youth soccer: a cluster-randomised controlled trial	Examine the effectiveness of a neuromuscular prevention strategy in reducing the number of injuries in young players (Football)
(110)	Distefano, L.; Padua, D.; Blackburn, T.; Garrett, W.; Guskiewicz, K.; Marshall, S. <i>Journal of strength and conditioning research</i> 4(2):332-42	2010	Integrated injury prevention program improves balance and vertical jump height in children	Establish the extent to which improvements to balance and strength in jumping can prevent injuries in children
(111)	Pasanen, K.; Parkkari, J.; Pasanen, M.; Hiilloskorpi, H.; Mäkinen, T.; Jarvinen, M.; Kannus, P. <i>BMJ</i>	2008	Neuromuscular training and the risk of leg injuries in female floorball players: cluster randomised controlled study	Investigate if a neuromuscular training programme is effective in preventing non-contact injuries in women (Floorball)
(112)	Zebis, M.K.; Bencke, J.; Andersen, L.L.; Døssing, S.; Alkjær, T.; Magnusson, P.; Kjær, M.; Aagaard, P. <i>Clin J Sport Med</i> 18(4):329-37	2008	The effects of neuromuscular training on knee joint motor control during sidcutting in female elite soccer and handball players	Develop a neuromuscular training programme over a season and experimentally analyse the neuromuscular adaptation mechanisms caused during a standard side-cutting move to the non-contact anterior cruciate ligament injury (Football and Handball)
(94)	Renkawitz, T.; Boluki, D.; Linhardt, O.; Grifka, J. <i>Sportverletzung-sportschaden</i> 21(1):23-8	2007	Neuromuscular imbalances of the lower back in tennis players - the effects of a back exercise program	Establish the risk of injury in athletes with neuromuscular imbalances of the back and implement a corrective programme (Tennis players)
(95)	Grindstaff, T.L.; Hammill, R.R.; Tuzson, A.E.; Hertel, J. <i>Journal of athletic training</i> 41(4):450-6	2006	Neuromuscular control training programs and noncontact anterior cruciate ligament injury rates in female athletes: a numbers-needed-to-treat analysis	META ANALYSIS Determine the risk reduction associated with neuromuscular training programmes aimed at preventing non-contact anterior cruciate ligament injury rates in female athletes
(113)	Herring, K.M. <i>Current sports medicine reports</i> 5(3):147-54	2006	A plyometric training model used to augment rehabilitation from tibial fasciitis.	Determine the effectiveness of a progressive plyometric training programme with an emphasis on the gradual development of the eccentric load to improve tibial fasciitis
(114)	McGuine, T. A.; Keene, J.S. <i>American journal of sports medicine</i> 34(7):1103-11	2005	The effect of a balance training program on the risk of ankle sprains in high school athletes	Assess the effectiveness of a balance training programme in reducing the risk of ankle sprains (High School)
(115)	Verhagen, E.; Van der Beek, A.; Twisk, J.; Bouter, B.; Bahr, R.; Van Mechelen, W. <i>The american journal of sports medicine</i> 32(6):1385-93	2004	The effect of a proprioceptive balance board training program for the prevention of ankle sprains	Assess the effectiveness of a proprioceptive balance programme in preventing ankle sprains (Volleyball)
Eccentric training work				
(116)	De Hoyo, M.; Pozzo, M.; Sanudo, B.; Carrasco, L.; Gonzalo-Skok, O.; Dominguez-Cob, S.; Moran-Camacho, E. <i>International journal of sports physiology and performance</i> 10(1):46-52	2015	Effects of a 10-week in-season eccentric-overload training program on muscle-injury prevention and performance in junior elite soccer players	Analyse the effect of an eccentric-overload training programme on muscle injury and the severity and performance among junior players (Football)
(117)	Petersen, J.; Thorborg, K.; Bachmann, M.; Budtz-Jørgensen, E.; Holmich, P. <i>The american journal of sports medicine</i> 39(11):2296-303	2011	Preventive effect of eccentric training on acute hamstring injuries in men's soccer	Investigate the preventive effect of eccentric hamstring muscle strengthening using the "Nordic Hamstring" exercise in comparison to other programmes with no additional hamstring exercises, on the acute hamstring injury rate (Football)
(118)	Andrew, P.; Lavendera, B.; Kazunori, N. <i>Journal of science and medicine in sport</i> 11:291-8	2008	A light load eccentric exercise confers protection against a subsequent bout of more demanding eccentric exercise	Hypothesis: A gentle eccentric exercise does not induce a loss in muscular function and has a protective effect during more strenuous eccentric activities.
(119)	Visnes, H.; Hoksrud, A.; Cook, J. <i>Clinical journal of sport medicine</i> 15(4):225-32	2005	No effect of eccentric training on jumper's knee in volleyball players during the competitive season - a randomized clinical trial	Explore the effect of an eccentric training programme on improving the patellar tendinopathy during a season (Volleyball)

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Warming up (FIFA programmes)				
(120)	McKay, C.D.; Steffen, K.; Romiti, M.; Finch, C.F.; Emery, C.A. <i>Br J Sports Med</i> 0:1-7	2014	The effect of coach and player injury knowledge, attitudes and beliefs on adherence to the FIFA 11+ programme in female youth soccer	Describe knowledge about injuries among young female football players and identify the relationship between the training load and injury through the "FIFA 11+" programme
(121)	Owoeye, O.; Akinbo, S.; Tella, B.; Olawale, O. <i>Journal of Sports Science and Medicine</i> 13:321-8	2014	Efficacy of the FIFA 11+ Warm-Up Programme in Male Youth Football: A Cluster Randomised Controlled Trial	Assess the efficacy of the "FIFA 11+" programme in the risk of injury among young male football players from the Lagos Junior League
(122)	Steffen, K.; Emery, C.A.; Romiti, M.; Kang, J.; Bizzini, M.; Dvorak, J.; Finch, C.F.; Meeuwisse, W.H. <i>British Journal of Sports Medicine</i> 47:794-802	2013	High adherence to a neuromuscular injury prevention program (FIFA 11+) improves functional balance and reduces injury risk in Canadian youth female football players : a cluster randomized trial	Evaluate if the different training methods of the "FIFA 11+" programme can improve player performance and prevent injuries
(123)	Steffen, K.; Meeuwisse, W.H.; Romiti, M.; Kang, J.; McKay, C.; Bizzini, M.; Emery, C.A. <i>British Journal of Sports Medicine</i> 47:480-7	2013	Evaluation of how different implementation strategies of an injury prevention programme (FIFA 11+) impact team adherence and injury risk in Canadian female youth football players: a cluster randomized trial	Assess the different training methods of an injury prevention programme (FIFA 11+) on adherence and injury risk among core female football teams
(124)	Longo, U.G.; Loppini, M.; Berton, A.; Marinozzi, A.; Maffulli, N.; Denaro, V. <i>The American Journal of Sports Medicine</i> 40(5)	2012	The FIFA 11+ Program Is Effective in Preventing Injuries in Elite Male Basketball Players	Examine the effects of the "FIFA 11+" programme in injury rates among elite male basketball players
(125)	Steffen, K.; Bakka, H.B.; Myklebust, G.; Bahr, R. <i>Scand J Med Sci Sports</i>	2008	Performance aspects of an injury prevention program: a ten-week intervention in adolescent female football players	Assess if the "FIFA 11+" programme can improve the performance of a group of female football players aged between 16 and 18 years

Physical control-Core-Core stability

Roetert¹²⁶ establishes that core stability is essential for good performance in almost all sports and activities. This is due to the tri-dimensional nature of many sporting movements, which require athletes to have good resistance in the hips and in the core muscles to provide an effective base stability.

Some sports require good balance, others strength, others physical symmetry, but all require good core stability in the three planes of movement¹²⁶. A lack of strength and core stability leads to ineffective technique, which leaves the athlete prone to injury¹²⁷. For example, lumbar pain is a common problem in any sport that requires twisting or extensive rotating movements and continuous bending and stretching movements¹²⁸⁻¹³⁰. Leetun *et al.*¹³¹ found that 41 basketball players (28 women, 13 men) out of 139 (35% of the women, 22% of the men), suffered 48 back or lower extremity injuries over the season. They revealed that the players that suffered an injury, generally did not have good core stability, due to a weak abduction and external rotation of the hip, which reduced their ability to maintain stability. The conclusion was drawn that lumbar-pelvic muscular requirements among women were greater, which led to them having a higher risk of suffering from lower back injuries. The conclusion was that core training could play an important role in preventing injuries, especially among women.

Physiologically, strength and core stability offer greater potential and more efficient use of shoulder, arm and leg muscles¹³², which entails a lower risk of injury and positive effects on sporting performance, in terms of speed, agility, power and aerobic resistance¹³³.

The preventive programmes that aimed to correct weak links in core ability are designed to¹³⁴:

- Increase joint mobility and muscle extensibility;
- Improve joint stability;
- Improve muscular performance;
- Optimise the function of movement.

Despite lower body strength being more important towards improving performance in certain sports that involve jumping, speed and agility, core resistance seems to be more important in preventing injury and recovery^{135,136}. McGill¹³⁵ upheld that developing core resistance should predominate over the development of strength in the lower body in order to prevent and recover from injury in the lower body.

Poor core stability can lead to muscular imbalances that predispose the appearance of painful syndromes⁹¹ and increase the possibility of injury to the lower body, in particular to the knee and the anterior cruciate ligament, due to poor alignment that causes overloading to the joints^{92,93} and the ankles^{100,101}.

When prescribing core stability exercises, the concept of specificity should take greater importance. Not all exercises are specific or bene-

ficial, as various studies have suggested¹³⁷⁻¹⁴¹. Research must continue on the effect of core stability in sporting performance. Some studies have implied that improving core stability and strength does not have an advantageous effect on sporting performance, based on conclusions drawn largely from basic tests^{142,143}.

Balance. Proprioception. Neuromuscular

The term proprioception was first introduced by Sherrington in 1906, who described it as a type of feedback from the limbs in the Central Nervous System. Since then, numerous authors have researched various aspects of proprioception and neuromuscular control. In modern day terms, a combination of posture, kinaesthesia and feelings of tension or strength are considered to be sub-forms of proprioception.

Limited balance ability is associated with a greater risk of falling and therefore a greater risk of injury¹⁴⁴. Improving balance with training exercises reduces the rate of sprained ankles¹⁴⁵ and the overall rate of injuries to the lower body^{95,105,108,111-113,115,146}.

The effects of proprioceptive training are: an increase in muscular activation, a reduction in reaction reflex times in stretching, improved inter-muscular coordination, balance and body awareness, and therefore a reduction in proneness to injury¹⁴⁴.

Exercises on unstable surfaces may increase the sensitivity of muscle spindles, improving their ability to respond more effectively to disrupting forces applied to a joint. Exposure to a combination of potentially destabilising forces during training may be a necessary stimulus in promoting the development of neuromuscular effective compensatory models¹⁴⁷. Paterno *et al.*¹⁴⁸ revealed improvements to the postural control of female athletes following a 6-week training programme that included balancing exercises performed on a Bossu ball, plyometric work, dynamic movement exercises and resistance exercises. Wedderkopp *et al.*¹⁴⁹ revealed that a dynamic warm up followed by ankle balance exercises reduced the chance of injury in the lower extremities in a team of female handball players. The control group was 6 times more likely to sustain an injury than the test group.

The programmes based on neuromuscular work are effective in reducing injuries and improving muscular imbalances^{94,104,106,109,110}.

Within neuromuscular work, tasks performed with a method based on plyometry (PLY) are noteworthy. Evidence available suggests that PLY, whether alone or in combination with others, causes numerous positive changes in the neural and muscular-skeletal system, in muscle function and sporting performance among healthy individuals.

Specifically, the studies have shown that over the long-term (3-5 sessions a week for 5-12 months), PLY constitutes an effective training method for improving bone mass in pre-pubescent and early pubescent individuals, young and pre-menopausal women. Furthermore, in the short-term (2-3 sessions a week for 6-15 weeks), PLY can alter the stiffness of various elastic components of muscular-tendon of plantar flexors among athletes and non-athletes¹⁵⁰. PLY over the short-term also improves lower body strength, the power of the stretching-shortening cycle of muscles (SSC) in healthy individuals. These adaptive changes to the neuromuscular functioning are probably the result of¹⁵⁰:

- Improvements to inter-muscular coordination;
- Changes to the mechanical characteristics of the muscle-tendon complex of plantar flexors;
- Changes to muscle size and/or architecture;
- Changes in the mechanics of a single fibre.

The results also show that PLY, whether used alone or in combination with other methods, has the potential of improving a wide range of sporting performances (jumping, speed races, agility, performance resistance) in children and young adults of both sexes, and reduce the risk of injury to the lower extremities in female athletes.

Although there are still many issues related to PLY still to address, the results allow for PLY to be recommended as a safe and effective training method to improve muscular function in the lower extremities, as well as acting as a functional training method for improving performance among healthy individuals^{102,103,114}.

Eccentric

Eccentric exercise (ECC) has been classically used to improve muscle strength and power in healthy individuals and athletes, and thanks to its physiological and specific mechanical properties, there is a growing interest in its use for clinical and rehabilitation purposes.

The majority of muscular injuries acquired in team sports are produced through explosive and eccentric type movements, which constitute one of the reasons why this type of work is advocated as a preventive method as well as a treatment for chronic injuries¹¹⁹.

Eccentric work may reduce the OI, the number of injury days and should be worked into sports injury prevention programmes for team sports¹¹⁸.

Petersen *et al.* carried out a study with 50 amateur and elite Australian football teams (n=942), implementing a 10-week eccentric hamstring strengthening programme using the Nordic Hamstring exercise. The control group had 52 injuries compared to the 15 injuries sustained by the intervention group¹¹⁷.

Hoyo *et al.* propose a 10-week programme, 3 sessions per week with 2 open stable kinetic hip exercises (Nordic curls) and one closed unstable exercise (2 lunges Bossu), emphasising the hamstring action and stabilising the knee in the eccentric work (1 eccentric leg dead lifts)¹¹⁶.

Another study based on a preventive programme for hamstring musculature that entails stretching, exercises for specific sports performed in fatigue, increase in the amount of time working at high intensities and anaerobic interval training as well as increasing the times worked at high intensity, were carried out among elite Australian football players (n=70) over 4 seasons, with the outcome of reducing lost match days from 31 and 38, to 5 and 16 and an OI of 4.7 to 1.3¹⁵¹.

Interest in eccentric work is based on:

Optimal length movement

It has been suggested that optimum muscle tension in each action can reduce the number of injuries¹⁵². The only training method that has been proven to consistently increase the optimum length of developing tension has been eccentric exercise^{152,153}. This fact has been proven in elbow flexes, plantar flexes and in flexes and extensors of the knee¹⁵⁴⁻¹⁵⁶. The extent of change depends on 3 variables: eccentric exercise load,

eccentric exercise volume and the length of the muscle during the eccentric muscular action.

Accentuated and supra-maximal load eccentric training

It has been shown that human beings are capable of recruiting a lower number of motor units (with the same development of strength) during an eccentric muscular action than during a concentric action. The neural efficiency of eccentric muscular actions is greater, which is why they have been suggested to maximise neural activation and the adaptation of subsequent strength. To perform these actions, greater loads are required¹⁵⁷. Some research has suggested that subjects may gain 20-60% more concentric and eccentric strength through eccentric training as opposed to concentric training¹⁵⁸.

Eccentric work to improve the S-S cycle (stretching-shortening)

Research has shown that when producing concentric strength, isolation is relatively low in comparison to concentric contractions that are preceded by an eccentric muscular action¹⁵⁹. This link is called SSC. The SSC may have large or small amounts of angular related movement of the joints and is composed of both voluntary and involuntary reflex actions¹⁶⁰. To get the optimum potential from SSC (a higher concentric contraction), various factors are essential:

- Pre-activation of muscle before the contact;
- No short coupling times (i.e. time between the end of the eccentric phase and the appearance of the concentric phase);
- Short-lasting contraction;
- High-speed eccentric muscle action;
- Small increase in movements.

Rehabilitation of specific injuries (tendinopathy of the Achilles tendon)

This work is based on the idea that injuries to the Achilles tendon may emerge from supporting traction loads that are higher than the tendon's mechanical resistance¹⁶¹. When these loads are repeated, as in many activities and sports, they may result in a symptomatic condition.

The theory of eccentric training, promoted for its importance in the structural adaptation of the symptomatic tendon establishes that it could be used when facing increasing repetitive loads and prevent injury¹⁶¹. The rehabilitation programmes that involve eccentric training using loads greater than the weight of the body have provided positive results in treating Achilles tendinopathy, with reduced pain and a greater number of patients returning to the pre-injury physical activity levels¹⁶².

Not all the studies give positive results, such as Visnes et al. who did not find improvements following the implementation of eccentric work to improve patellar tendinitis over 12 weeks among volleyball players that continued to compete whilst the programme was underway¹¹⁹.

Isokinetic tests¹⁰⁷

Whenever the opportunity arises, it is recommendable to perform isokinetic tests to establish the agonistic-antagonistic relationship and the possible strength deficits that leave the player prone to injury.

Specific warm ups

Different studies show that by including a specific, dynamic warm up, of between 15-20 minutes, where coordination, balance and strength are all worked, there is an improvement to the postural balance and the risk of injury is reduced. Of particular interest are the studies

based on the programme developed by FIFA, called FIFA 11+, which consisted in 10 exercises that worked on core stability, lower extremity strength, balance and agility¹²⁰⁻¹²⁵, in which all revealed a reduction in the risk of injury.

Table 4 studies found on Injury Prevention analyzed. Other preventive measures.

Blood tests. Supplementing

Blood testing among sportspeople is a long-recognised method for establishing the health of the individual, if training is being assimilated properly, and if some kind of supplementing is necessary, with the most common being iron due to anaemia induced through practicing sports^{163, 64}.

Biometric analysis

Biomechanical studies and/or video analysis may reveal new ways of reducing the OI and should be part of a preventive work in which they are observed, analysed and then a series of measures are applied to them with the aim of re-training movements and reducing the possibility of injury. In basketball, and more so in women, due to their predisposition to valgus knee, it is important to study landing after a jump. Biomechanical studies can allow us to analyse the movement phases with precision, establishing the loads that are supported upon landing and allowing for the prediction of sportspeople that are at greater risk of having certain types of injury^{165, 166}.

Material and regulations

Many sporting injuries are the result of unavoidable accidents, but there are also many that could be prevented. Taking measures such as altering the rules of play, especially in team and contact sports, should be considered with the objective of reducing the number of violent contacts between participants. There are interventions that have included changes to the rules, involving large groups of participants, and proving to be effective in reducing injuries^{173, 174}. This is the case of concussions¹⁷⁵. These measures include changes to the rules to avoid impact to the head, conditioning of the neck muscles, the use of mouth-guards and the use of helmets and head protectors.

The use of protective devices may also result in unexpected consequences, for example, skiers that use helmets can ski harder, closer to their limits, and under worse conditions, supposing that the helmet protects the head, whereas in reality this change in behaviour leads to an even greater risk of injury. The sporting material used can undoubtedly prevent injury, or on the contrary, increase them.

Facial injuries are common in a significant number of sports; thanks to the more systematic use of helmets and face-guards, injury rates have fallen¹⁷⁶. In the USA alone, it was estimated that over 1,600 eye injuries were sustained in different forms of hockey in 1997¹⁷⁷. However, since 1997, no major eye injuries have been registered among the over 1 million players that wore fully-certified hockey masks¹⁷⁸.

In the case of sports footwear (trainers, boots, skates, etc.), it is of equal importance to ensure they have the correct properties, i.e. of stiffness, absorption, etc. required for each sport¹⁶⁷⁻¹⁶⁹. Based on the literature available, Robbins and Waked¹⁷⁸ reached the conclusion that in terms of the feeling the foot position in human beings, being barefoot is necessary but sporting footwear distorts feet, increasing the

Table 4. Prevention of injuries. Other preventive measures.

Authors, Journal & Reference	Year	Article	Objective / Hypothesis
Training load & control & team sports (n=3)			
Blood test-Supplementing			
(163) Claudino, Joao G.; Mezencio, Bruno; Amaral, Sergio. <i>Journal of the international society of sports nutrition</i> 11(32)	2014	Creatine monohydrate supplementation on lower-limb muscle power in Brazilian elite soccer players	Examine the effects of creatine-monohydrate supplementation on lower-limb muscle power in Brazilian elite football players
(164) Bizzaro, N. <i>Recenti progressi in medicina</i> 80(5):237-40	1989	Study of variations in hematologic parameters in rugby players undergoing physical training at a high altitude	Prove that well-trained rugby players can develop mild anaemia due to the increase in plasma volume with a relative reduction of red blood cells
Biomechanical Analysis			
(165) Pietraszewski, B.; Struzik, A. <i>Acta of bioengineering and biomechanics</i> 15(4):103-8	2013	Evaluation of selected biomechanical parameters in female team sports players	Assess the biomechanical parameters of lower limbs and their influence in the height of vertical jumps
Prevention injuries & training load (n=7)			
Biomechanical Analysis			
(166) Myer, G.D.; Ford, K.R.; Barber, K.D.; Rauh, M.J.; Paterno, M.V.; Hewett, T.E. <i>Journal of Athletic Training</i> 49(3):389-98	2014	A Predictive Model to Estimate Knee-Abduction Moment: Implications for Development of a Clinically Applicable Patellofemoral Pain Screening Tool in Female Athletes	Identify biomechanical laboratory measures to precisely measure the loads supported during landing and predict a greater risk of injury among female athletes
Material			
(167) Fourchet, F.; Kuitunen, S.; Girard, O.; Beard, A.J.; Millet, J.P. <i>Journal of Sports Science and Medicine</i> 10:292-300	2011	Effects of combined foot/ankle electromyostimulation and resistance training on the in-shoe plantar pressure patterns during sprint in young athletes	Investigate the influence of a five-week ankle and knee strengthening training programme on the in-shoe plantar pressure patterns during sprint in young male athletes
(168) Lohrer, H.; Turbanski, S.; Nauck, T.; Schmidtbleicher, D. <i>Sportverletzung-sportschaden</i> 22(4):191-5	2008	Balance Therapy Shoes - a Comparative Analysis with Respect to Immediate Training Effects	Hypothesis: Using a different shoe to that normally used entails a different load supported by the neuromuscular system that affects postural control
(169) Eils, E.; Streyll, M. <i>Sportverletzung Sportschaden</i> 19(3):140-5	2005	A one year aging process of a soccer shoe does not increase plantar loading of the foot during soccer specific movements	Assess the influence of a controlled ageing process on a foot load model inside a football shoe
Public Health			
(170) Finch, C.F. <i>British journal of sports medicine</i> 46(1):70-4	2012	Getting sports injury prevention on to public health agendas - addressing the shortfalls in current information sources	Hypothesis: The main reason behind a lack of sports injuries policies in Government Departments for health or sport till now is a lack of relevant information made available to the politicians in charge for decision-making
Educational Intervention			
(171) Myer, G.D.; Faigenbaum, A.D.; Chu, D.A.; Falkel, J.; Ford, K.R.; Best, T.M.; Hewett, T.E. <i>Physician and sportsmedicine</i> 39(1):74-84	2011	Integrative Training for Children and Adolescents: Techniques and Practices for Reducing Sports-Related Injuries and Enhancing Athletic Performance	REVIEW Review the scientific evidence available on youth and conditioned strength training and offer recommendations that are appropriate for each age to integrate them into the different strength and conditioning activities in a well-designed programme that is safe, effective and enjoyable
(172) Cook, M.; Cusimano, C.H.; Chipman, M.L. <i>Injury Prevention</i> 9:361-6	2003	Evaluation of the ThinkFirst Canada, Smart Hockey, brain and spinal cord injury prevention video	Assess the knowledge and adherence to the "ThinkFirst Canada" programme about preventing injuries that shows the mechanisms and onsequences of brain and spinal injuries acquired whilst playing ice-hockey among 11-12 year old children practicing this sport.

frequency of ankle sprains while using sporting footwear. They suggest that the best solution for reducing ankle sprains while using sport shoes is to use footwear that offers a maximum level of sensitivity, thus being aware of the foot's position.

The positive preventive effect of ankle stabilisers has been revealed in different studies¹⁷⁹⁻¹⁸¹. The use of shock-absorbing soles in footwear reduces the incidence of fractures due to overloading among athletes¹⁸²⁻¹⁸⁶. Gillespie and Grant¹⁸⁷ calculated, using their systematic Cochrane review, that in accordance with these trials, the use of shock-absorbing soles reduces the risk of stress fractures by 53%. However, these authors expressed their concern regarding the relatively low quality of these 5 trials.

Despite prophylactic ankle stabilisers appearing to prevent some ankle injuries, once again, more research is required with other prophylactic interventions and their general applicability^{188,189}.

Public Health¹⁷⁰

Injuries have moved through the sporting sphere, reaching all sectors of the population to the point that they have been considered as public health concerns with the subsequent intervention of governmental departments.

Until research in sports medicine produces information about the population and cost-benefit estimations, the prevention of sporting injuries will continue to be undervalued within the public health sphere, due to the lack of relevant information available that would allow political leaders to make decisions and implement measures.

Educational intervention

Education-Training from childhood

It is important to establish age-appropriate training guidelines that may reduce the risk of sport-related injuries and improve sporting performance. Integrative Training is defined as a programme or plan that incorporates strength and conditioning into general and specific activities that improve both components, such as health and physical condition¹⁷¹.

The keystone of integral training is age-appropriate education and teaching by qualified professionals that understand the physical and psychosocial uniqueness of children and adolescents.

Educational intervention programme

To date, existing data about OI, injury factors and mechanisms in different sports and the preventive measures that have proven effective, may be used to educate young athletes, despite them facing a low risk of injury, given that a good understanding of the risks is likely to generate a preventive effect¹⁹⁰.

In team sports, it is generally necessary to have a larger focus on reducing rough and violent contact between athletes.

Ice hockey is a good example of preventive measures of this type. To avert spinal injuries aggressive behaviour should be avoided, especially if sustained from behind or next to the rink barriers, and should be penalised by the rules of play. The use of contact with the stick in this sport partly explains the high number of hand injuries and wrist fractures sustained, and should be controlled¹⁹¹. With the aim of reducing OI in ice hockey, a Canadian programme was implemented called "Think

first"¹⁷², with the objective of assessing the transfer of knowledge and results to 11 and 12-year old players via a video, explaining how to avoid injuries, injury mechanisms and their consequences, with particular emphasis on brain and spinal injuries. The results indicated that after just one viewing their knowledge improved, as did their behaviour on the rink, and stayed that way for three months, though they indicate that a greater number of samples would be necessary.

In Table 5 the studies found on Injury Prevention anterior cruciate ligament (ACL) are analyzed.

Anterior cruciate ligament injuries (ACL) are among the most worrying in team sports, as these injuries may have serious consequences for the sports person with a high risk of early-onset osteoarthritis and are considered one of the most serious frequently occurring injuries^{193,199,200}.

The capacity to design specific prevention programmes is currently limited by an incomplete understanding of the causes of injury. A multi-factorial approach should be used to appreciate all the factors involved, internal and external, as well as the causes of the injury and a description of the entire body and biomechanics together at the time of the injury.

Again, the previously seen aspects (general and mode-specific strength work, physical control, balance, proprioception, neuromuscular, eccentric) seem to be the bases of ACL injury prevention.

Physical control-Core-Core stability

Core stability exercises have been defended in the prevention and rehabilitation of lower extremity injuries^{211,212}.

Power and stability training of the core, along with the correct alignment of the lower extremities, result in a lower loading of the knee and reduce knee injury risk factors^{91,93,194,195,197,203,208,209}.

The body's core forms a base upon which the lower extremity muscles produce or resist strength. Several of the muscles that act on the knee joint originate from the pelvic lumbar region.

McGill¹³⁵ establishes that developing core resistance should take priority over developing lower body strength in order to prevent and recover from lower body injuries. For example, a lack of core muscle conditioning may result in a defective landing mechanism with the increase of valgus type exertions acting on the knee joint, which could lead to an anterior cruciate ligament injury (ACL).

Movement re-training techniques

The studies that implemented intervention programmes to re-train both the stride technique while running and the most basic and common movement action in team sports, such as in basketball, handball, football, indoor football, where running stops followed by a jump and subsequent landing, called the "stop and jump task" in some articles, are of particular interest.

These programmes seek to avoid poor alignment of the hip, knee and ankle, such as the valgus position, insufficient flex of the knee and hip flexion^{97,99,107,166,192,196-198,201,202,205-207,210}.

Balance. Proprioception

Research has revealed the effectiveness of exercises performed on unstable surfaces in reducing the possibility of injuring the ACL^{211,212}.

Myklehust *et al.*²¹³ establish that plyometric and balance exercises significantly reduce the risk of ACL injuries in elite handball players.

Table 5. Prevention of injury to the anterior cruciate ligament (ACL).

Authors, Journal & Reference	Year	Article	Objective/Hypothesis
Training load & control & team sports (n=9)			
(192) Dempsey, Alasdair R.; Elliott, Bruce C.; Munro, Bridget J. <i>Journal of applied biomechanics</i> 30(2):231-6	2014	Can technique modification training reduce knee moments in a landing task?	Assess if the landing technique is involved in the injury of the ACL
(193) Donnelly, C. J.; Elliott, B. C.; Ackland, T. R. <i>Research in sports medicine</i> 20(3):239-62	2012	An anterior cruciate ligament injury prevention framework: incorporating the recent evidence	REVIEW Review the scientific evidence on ACL injury mechanisms
(194) Hewett, Timothy E.; Myer, Gregory D. <i>Exercise and sport sciences reviews</i> 39(4):161-6	2011	The mechanistic connection between the trunk, hip, knee, and anterior cruciate ligament injury	Hypothesis: The lateral movement of the core increases the load and neuromuscular training improves core control, reducing the load borne by the knees.
(195) Cochrane, Jodie L.; Lloyd, David G.; Besier, Thor F. <i>Medicine and science in sports and exercise</i> 166(42):1535-44	2010	Training affects knee kinematics and kinetics in cutting maneuvers in sport	Examine how different training forms affect the kinematics of the knee during different actions and the potential of these forms in reducing the ACL loading
(196) Dworak, Lechoslaw B.; Rzepnicka, Agata.; Wilkosz, Piotr. <i>Chirurgia narzadow ruchu i ortopedia polska</i> 75(1):35-41	2010	Analysis of knee joint injuries of competitive volleyball players in selected sports clubs of poznan city-biomechanical context. Synthesis-proposal for the usage of physiotherapy methods in the prevention of the discussed injuries.	Analyse the frequency and type of injury in knee joints that occur in elite volleyball players, as well as how to propose the use of modern physiotherapy with the aim of preventing these injuries (Volleyball)
(197) Dempsey, Alasdair R.; Lloyd, David G.; Elliott, Bruce C. <i>American journal of sports medicine</i> 37(11):2194-200	2009	Changing sidestep cutting technique reduces knee valgus loading	Hypothesis: Modifying the sidestep cutting technique could reduce knee loading
(198) Imwalle, Lauren E.; Myer, Gregory D.; Ford, Kevin R. <i>Journal of strength and conditioning research</i> 23(8):2223-30	2009	Relationship between hip and knee kinematics in athletic women during cutting maneuvers: a possible link to noncontact anterior cruciate ligament injury and prevention	Compare the kinematics of the lower extremities to 45° and 90° during the sidestep cutting action and examine the rotations of the lower extremities during these actions
(199) Renstrom, P.; Ljungqvist, A.; Arendt, E. <i>British journal of sports medicine</i> 42(6):394-412	2008	Non-contact acl injuries in female athletes: an international olympic committee current concepts statement	REVIEW Review the ACL injury mechanisms in female athletes
(200) Petersen, W.; Rosenbaum, D.; Raschke, M. <i>Deutsche zeitschrift fur sportmedizin</i> 56(6):150-6	2005	Anterior cruciate ligament ruptures in female athletes. Part 1: epidemiology, injury mechanisms, and causes	REVIEW Review the epidemiology, the injury mechanisms and the causes of injury of the ACL in female athletes
Prevention injuries & training load (n=10)			
(201) Aerts, I.; Cumps, E.; Verhagen, E.; Wuyts, B.; De Gucht, S.V.; Meeusen, R. <i>Journal of sport rehabilitation</i> 24(1):21-30	2015	The Effect of a 3-Month Prevention Program on the Jump-Landing technique in Basketball: A Randomized Controlled Trial	Assess the influence of an anterior cruciate ligament injury prevention programme by teaching jumping and landing techniques
(202) Dai, B.Y.; Garrett, W.E.; Gross, M.T.; Padua, D.A.; Queen, R.M.; Yu, B. <i>American journal of sports medicine</i> 43(2):466-74	2015	The Effects of 2 Landing Techniques on Knee Kinematics, Kinetics, and Performance During Stop-Jump and Side-Cutting Tasks	Assess the effect of an intervention programme aimed at improving the jumping and landing technique, on the anterior cruciate ligament injury rate
(203) Myer, Gregory D.; Ford, Kevin R.; Brent, Jensen L.; Hewett, Timothy E. <i>Strength cond res.</i> 26(8):2272-92	2012	An integrated approach to change the outcome part ii: targeted neuromuscular training techniques to reduce identified acl injury risk factors	Propose an integrated approach to identify and select mechanical bases that explain the increase in ACL injuries among female sportswomen
(204) Greska, Eric K.; Cortes, N.; Van Lunen, Bonnie L.; Oñate, James A. <i>J strength cond res.</i> 26(6):1609-19	2012	A feedback inclusive neuromuscular training program alters frontal plane kinematics	REVIEW

(keep going)

(205)	White P.E.; Ullah, S.; Donaldson, A.; Otago, L.; Saunders, N.; Romiti, M.; Caroline, A.; Finch, F. <i>Journal of Science and Medicine in Sport</i> 15:19–24	2012	Encouraging junior community netball players to learn correct safe landing technique	Understand the behavioural factors associated with the correct landing technique during training sessions with junior netball players to reduce the risk of anterior cruciate ligament injury
(206)	Aerts, I.; Cumps, E.; Verhagen, E.; Meeusen, R. <i>BMC Musculoskeletal Disorders</i> 11, 281	2010	Efficacy of a 3 month training program on the jump-landing technique in jump-landing sports. Design of a cluster randomized controlled trial	Assess the effect of an intervention programme aimed at improving the jumping and landing technique, on the anterior cruciate ligament injury rate (ACL)
(207)	Herrington, L. <i>Journal of strength and conditioning research</i> 24(12):3427-32	2010	The effects of 4 weeks of jump training on landing knee valgus and crossover hop performance in female basketball players	Assess whether a reduced jumping programme could have similar effects to previously reported longer-lasting programmes in preventing anterior cruciate ligament injuries
(208)	Myers, C.A.; Hawkins, D. <i>Journal of biomechanics</i> 43(14):2657-64	2010	Alterations to movement mechanics can greatly reduce anterior cruciate ligament loading without reducing performance	Identify biomechanical changes that sportspeople can perform to reduce anterior cruciate ligament loading
(209)	Myer, Gregory D.; Ford, Kevin R.; Brent, Jensen L.; Hewett, Timothy E. <i>BMC musculoskeletal disorders</i> 39(8)	2007	Differential neuromuscular training effects on ACL injury risk factors in "high-risk" versus "low-risk" athletes	Establish the effect of neuromuscular training among athletes classed as "high-risk" of suffering ACL injuries in comparison with those classed as "low-risk" Hypothesis: high-risk athletes will reduce abduction stages whilst low-risk athletes will not show any measurable changes
(210)	Dempsey, A.R.; Lloyd, D.G.; Elliott, B.C.; Steele, J.R.; Munro, B.J.; Russo, K.A. <i>Medicine & Science in Sports & Exercise</i> 39(10):1765-73	2007	The effect of technique change on knee loads during sidestep cutting	Identify the effect of modifying the sidestepping technique on the knee and predict what impact the change will have on the risk of injuring the anterior cruciate ligament

Caraffa *et al.*²¹⁴ reported significantly fewer ACL injuries among semi-professional and amateur football players after performing a balance exercise programme in training.

Padua²¹⁵ revealed that performing balance and plyometric exercises in training influences the capacity to change the biomechanics of the use of the lower extremities in more damaging movements, thus reducing the risk of injury to the knee and rupture of the ACL.

Despite this evidence and the frequent incorporation of balance exercises into injury prevention programmes, only a few studies have actually assessed and proven the influence of balance work on preventing ACL rupture²¹⁶.

Neuromuscular and proprioceptive work is very important in both preventing^{94,106,110,204,209} and avoiding recurrences. Fitzgerald, Hacha and Snyder-Mackler²¹⁷ assessed the effectiveness of a training programme with imbalances as a complement to rehabilitation exercises. The intervention group that worked within this programme were 5 times more likely to successfully return to vigorous sporting activities.

Neuromuscular work should be included within weekly training loads, as it is appropriate for compensating muscular imbalances, increasing strength and protecting the body from all kinds of injury, including non-contact anterior cruciate ligament rupture, reducing, among other aspects, valgus knee.

A successful return to previous activity levels following the reconstruction of the anterior cruciate ligament (ACL) is not guaranteed, and the likelihood of sustaining a second ACL injury may reach 30%. In

particular, young athletes that return to sporting activities in the first months following a first ACL reconstruction may have a significantly greater risk than after a second.

Significant neuromuscular deficits and functional limitations are commonly identified among athletes with ACL reconstruction. Unusual movements and a lack of neuromuscular control may be both residual, from deficits that were already present before the initial injury, and exacerbated through the injury and the subsequent ACL reconstruction surgery. Following ACL reconstruction surgery, neuromuscular deficits are present in both surgical and non surgical extremities, and may precisely predict the risk of a second ACL injury in adolescent athletes.

All the work reviewed revealed a reduction in the risk on injury and a lower OI in the intervention group after implementing work of this type.

Conclusions and personal opinion

- Preventing injury has become one of the technical team's most important objectives, if not the most important, and is a component within the training programme with its very own fundamental organisation.
- Work should continue to develop on consensus regarding the work methodology to be followed, allowing for enhanced study comparisons.
- Load monitoring should involve the collecting of quantitative and qualitative data, both within and outside training (recovery

capacity) and should consider the sensations of the athlete and the possible deviations between the technical team plan and that carried out by the athlete.

- General and specific strength work, with particular emphasis on eccentric work, along with proprioceptive control and neuromuscular coordination, shape the basic pillars upon which an injury prevention plan is based. This type of work is based around enhancing all the active protection mechanisms through systematised stimulation which obliges athletes to control, think about and internalise their movements, giving them greater control over them.
- An on-going review of the rules of play and protection materials should be considered, as they lead to a reduction in incidents incurring injury.
- Biomechanical and video studies should continue, both laboratory and field based, which allow for on-going progress in the knowledge of the causes and factors of injuries.
- Injuries have expanded out of the sporting world and have reached the general population. Epidemiological studies are needed regarding injury incidents in the general public, which would allow us to assess the magnitude of the situation.
- Prevention has been shown to be cheap and effective when compared to the economic, sporting and labour costs caused by injuries, even if it is difficult to assess how many injuries are produced through inadequate sports training and how many are averted through adequate sports training.
- Efforts should be continued to promote injury prevention from the global perspective of the athlete from childhood, where perhaps the real prevention can be found, through:
 - Medical checks adapted to each life stage
 - Developing complete physical activity programmes that entail a domain over basic movement models and abilities in different situations and across all fields and planes.
 - Develop general and specific educational intervention programmes that explain the occurrence of injuries, their causes, factors and consequences.

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Effectiveness of eccentric exercise in patellar tendinopathy. Literary review

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Summary

Introduction: Chronic patellar tendinopathy is described as the appearance of pain, inflammation and a loss of function of the patellar tendon. It is a pathology that develops through overuse in sports that involve racing, repetitive trauma and jumps.

Objectives: Demonstrate the effectiveness of eccentric exercises on patellar tendinopathy, analysing some of the physiological changes that occur to the tendon and attempt to establish a protocol of specific exercises.

Materials and methods: A literary search was performed of the Cochrane, ScienceDirect, Pubmed and PEDro databases. 10 articles were found that compared eccentric exercises with shockwaves, concentric exercises, a night-worn splint and stretches, grading improvements in pain, function and the quality of life of the patients.

Results: The eccentric exercises were effective in treating patellar tendinopathy in comparison with other therapies such as shockwaves, stretches, night-worn splints, etc. In some of these articles evidence emerged regarding the effectiveness of eccentric exercises, in others the possibility was left open for continued research into the existence of a combination of various therapies, perhaps being the most effective and quick way of recovering from this injury.

Conclusion: Eccentric exercises are effective in treating patellar tendinopathy; however, no evidence has shown that they are better than other currently applied treatments. On the other hand, no specific protocol for applying these exercises has been established.

Key words:

Tendinopathy.
Eccentric. Patellar.

Eficacia de los ejercicios excéntricos en tendinopatías rotulianas. Revisión bibliográfica

Resumen

Introducción: La tendinopatía crónica rotuliana se describe por la aparición de dolor, inflamación y pérdida de la función del tendón rotuliano. Es una patología desarrollada por el uso excesivo en deportes que implican carreras, traumatismos repetitivos y saltos.

Objetivos: Evidenciar la eficacia de los ejercicios excéntricos en las tendinopatías rotulianas, analizar algunos de los cambios fisiológicos que se dan en el tendón e intentar determinar un protocolo de ejercicios concreto.

Materiales y métodos: Se ha realizado una búsqueda bibliográfica en las bases de datos Cochrane, ScienceDirect, Pubmed, PEDro. Se han encontrado 10 artículos donde se han comparado los ejercicios excéntricos con ondas de choque, ejercicios concéntricos, férula de noche y estiramientos, valorándose la mejora del dolor, la función y la calidad de vida de los pacientes.

Resultados: Los ejercicios excéntricos han sido efectivos en el tratamiento de la tendinopatía rotuliana, en comparación con otras terapias como las ondas de choque, estiramientos, férulas de noche, etc. En algunos de éstos artículos se evidencia la eficacia de los ejercicios excéntricos, en otros deja abierta la posibilidad de seguir investigando en la existencia de combinación de varias terapias, pudiendo ser más efectiva y rápida la rehabilitación de esta lesión.

Conclusión: Los ejercicios excéntricos son efectivos en la tendinopatía rotuliana, sin embargo no se ha demostrado que sean superiores a otros tratamientos aplicados actualmente. Por otro lado, no se ha podido determinar un protocolo concreto de aplicación de estos ejercicios.

Palabras clave:

Tendinopatía.
Excéntrico. Rotuliano.

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Introduction

Anatomical Note

Tendinopathy is a clinical syndrome that describes the injuries caused through overuse of the tendon. It is characterised by a combination of pain, diffuse or localised inflammation, and a loss of function. It is a failing response to healing, associated with the degeneration of tendon cells, a disorder of the collagen fibres, an increase in the cellular matrix without collagen along with neurogenic inflammation¹.

The patellar tendon is one of the most powerful in the human body: it is 4 or 5 centimetres long by a little under 3 cms wide, and approximately 1 cm thick². It can be considered part of the Extensor Apparatus of the Knee, made up of the quadriceps muscle, quadriceps tendon, the kneecap and the patellar tendon, which goes into the tibia. It is a fundamental structure in order to stand up with the weight of gravity, to walk, run and jump^{3,4}.

The nomenclature surrounding chronic pain of this tendon is confusing. Up to a few years ago, chronic patellar pain was considered to be marked by the presence of an inflammatory component, and the terms tendinitis and tendinosis were frequently used.

Today, the histological assessment of biopsies, intra-tendon microdialysis and technological genetic analyses of the biopsies have all revealed that there are no signs of inflammation due to prostaglandin and therefore, these terms should not be used. On the other hand, it has been shown that the tendons are metabolically more active; today the term tendinopathy is used to assign chronic painful symptoms in a sensitive and painful area of the tendon⁵.

These clinical pictures can be complicated by the inflammation of the external covering of the tendon, called the para-tendon. Inflammation of this connective covering may make an isolated appearance, earning the name of para-tendinitis, or in connection with a tendinopathy or tendinosis, almost always characterised by a grating of the structure⁶ (Table 1).

The clinical presentation is variable: often characterised by pain in the front part of the knee which initially does not prevent the activity but over time, if it is not diagnosed and treated, progresses in such a way that the pain is incapacitating, continues after exercise, and may

Table 1. Classification of tendinopathies (adapted from Brukner and Khan, 1993)⁷.

Diagnosis	Microscopic findings
Tendinosis	Tendon degeneration caused by age, ageing of the connective tissue, overuse and vascular disorder
Tendinopathy /Partial rupture	Symptomatic degeneration with vascular disruption
Para-tendinitis	Inflamación del paratendón, sin tener en cuenta si está cubierto o no de sinovial
Para-tendinitis with tendinosis	Para-tendinitis associated with intra-tendon degeneration

even cause problems in everyday life, causing pain when walking, going down stairs, sitting, etc⁷.

In 1973, Blazina⁸ suggested a symptom-related classification to assess the state of the injury:

- I. Pain after the activity.
- II. Pain during and after the activity.
- III. As above but prevents the athlete from performing the activity.
- IV. Tendon rupture.

Despite the specific aetiology being unknown, it is prevalent among people that are sedentary, overweight, elderly, have mellitus diabetes, hypertension, dyslipidaemia, rheumatoid arthritis, or other inflammatory conditions, consume certain antibiotics, etc.⁹⁻¹¹. On the other hand, it is linked to environmental conditions and training errors, along with some morphological differences (poor alignment of the patellar, weakness or muscular imbalance, reduction of flexibility, joint laxity, etc.). In other cases it may arise due to alterations in the vascularisation or genetic predisposition of the patient¹².

Protocols and current treatment

Conservative treatment starts by correcting both intrinsic and extrinsic aetiological factors, e.g. biomechanical corrections whilst performing exercise¹³.

On the other hand, there are a wide range of possibilities within rehabilitation, such as shockwaves, low-intensity laser, splints, injections (corticoids, heparin, dextrose, Glycosaminoglycan polysulphates (GA-GPS), autologous growth factors (Platelet-Rich Plasma), etc.) cryotherapy, stretches, ultrasound...^{4,5,8,10,11}

A common treatment used is that of eccentric exercises or those that generate contraction strength whilst the muscle elongates¹⁴.

Eccentric exercises were initially proposed by Stanish and Curwin in 1986, planning 6 weeks of eccentric exercises among 200 patients with Achilles tendinopathy, which obtained a complete improvement in 44% of patients and a considerable improvement in 43% of patients. They were performed once a day, increasing the performance speed¹⁵.

Later, in 1998, Alfredson (9) proposed 6 series of 15 repetitions of eccentric exercises (3 series with the knee extended and 3 flexed) performed twice a day, every day over 12 weeks. The exercises progressed by increasing the load, always carried out slowly, suggesting that their performance was not speed-dependant.

Surgical treatment will be implemented with patients whose conservative treatment has previously failed¹⁶.

Objetives

- Observe the existing scientific evidence regarding the effectiveness of applying eccentric exercises on patellar tendinopathy.
- Compare eccentric exercises with other physiotherapeutic treatments that are currently applied to patellar tendinopathy.
- Prove some of the physiological effects of eccentric exercises on the tendon.
- Establish, if it exists, a protocol of specific eccentric exercises to be applied to patients with patellar tendinopathy.

Material and method

For this systematic review, similar reviews were used, randomised controlled trials (RCT) and meta-analyses that are controlled and randomised studies.

The search was performed within the following databases: PubMed, The Cochrane Library, ScienceDirect, PEDro. (Figure 1).

The keywords used according to the terminology described in MeSH were:

- "Tendinopathy".
- "Exercise therapy".
- "Tendon".
- "Patellar tendon".
- "Chronic tendinopathy".
- "Eccentric".

Selection criteria

Inclusion criteria:

- Articles from 2008 to 2014.
- Articles whose subjects/participants were of both sexes.
- Articles related to chronic patellar tendinopathy.
- Articles in English and Spanish.

Exclusion criteria:

- Articles with less than 30 participants.
- Studies with participants aged under 18 or over 65 years.
- Articles that were not controlled and/or randomised trials.
- Not related to eccentric exercises and the treatment of chronic patellar tendinopathy.

Results

After searching through the various aforementioned databases, 134 articles were obtained in total. A selection was performed taking into account the titles (70 articles were selected). Then the abstracts were read to establish whether or not the selected studies were valid for this systematic review.

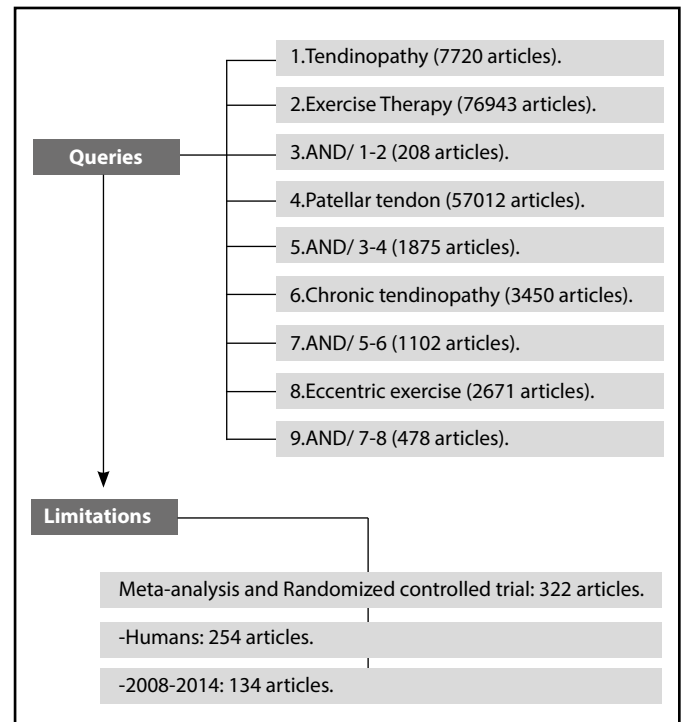
When the abstract reading was not enough to decide which articles to choose, the entire study text was read (this was performed in 47 articles).

This meant that of the 134 articles identified using the literary search, 47 were selected to be assessed in more detail and to be read in full. Two articles were excluded as they did not provide results. Another was excluded as it did not correspond to the type of study for inclusion in this review.

Next, the articles were selected or excluded depending on the previously mentioned selection criteria. 26 articles were excluded from the review for not adhering to these criteria.

After excluding all the studies that did not adhere to the selection criteria required for inclusion within the study, the review of the entire texts of the selected studies was repeated, this time with the aim of evaluating if the study included a clearly described rehabilitation process of tendinopathy through the use of eccentric exercises (8 studies were excluded).

Figure 1. PubMed search explanation.

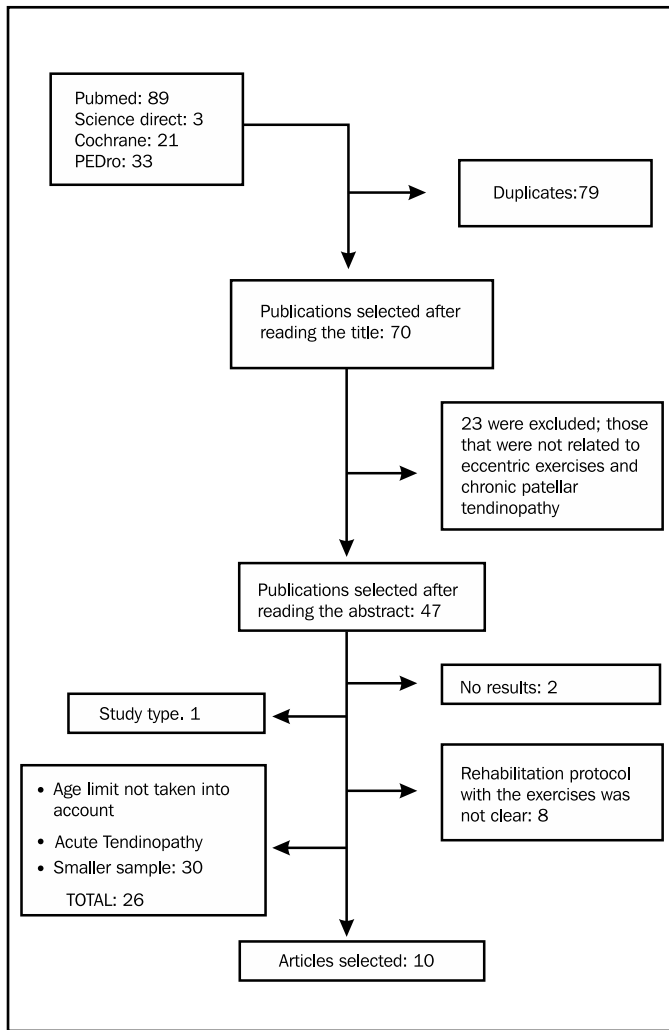


Once the suitable articles had been established, a comprehensive reading of these articles was carried out to prove the effectiveness of eccentric exercises. 10 articles were selected for this review (Figure 2 and Table 2).

In this review, the majority of the articles showed evidence of the effectiveness of eccentric exercises, though a large part of the articles added nuances. In the 2008 article by Cook *et al.*¹⁸, the number of participants was divided into two groups to perform exercises following the Alfredson protocol, differentiating the position of the ankle. The first group performed the eccentric exercises with their feet in a neutral position (Figure 3)¹⁶ and the other group performed the same exercises with their feet on the affected side in plantar flexion position (Figure 4)¹⁶. The results obtained by Cook *et al.* in 2008¹⁸ were very similar in both groups, but one of the assessment disadvantages was that the study did not specify if all the injuries were located in the same place in all the participants or if they were located in different parts of the tendon. Another article by Mark Young *et al.* in 2010¹⁶ also compared the performance of exercises on a plane tilted at 25° and another on a flat plane, the results of this study alluded to the fact that both protocols were optimum for tendon rehabilitation, but that after 12 months using a tilted plane, better results were achieved on the VISA scale, with no improvement difference shown between the groups within 12 months. However, in the 2009 article by Rees *et al.*¹⁹ it is revealed that for patellar inserted tendinopathies, standard eccentric exercises are ineffective, suggesting the possibility of continuing research on eccentric exercises and the most effective postures depending on the location of the injury.

In other studies, eccentric exercises were compared to other types of exercise (concentric, shockwaves, plasma infiltration, ultrasound, etc.).

Figure 2. Flowchart explaining the selection criteria.



Eccentric exercises vs. concentric exercises

In 2012, Jonsson *et al.*³ compared concentric and eccentric exercise in the treatment of tendinosis. The pain and mobility of the knee were assessed before, during and after the 12-week intervention programme. When the authors assessed both the movement and pain after 4 weeks, the eccentric exercises group had significantly less pain. It was observed that eccentric exercises were effective in encouraging the formation of tendon collagen fibres, facilitating its remodelling (Figure 5).

In 2008, Cannell *et al.*²⁰ compared squats and concentric knee flexion and extension exercises for the treatment of knee tendinosis. They assessed the pain, extension of the knee and the flexor torque. No significant differences were found between the groups in any of the aspects assessed.

Eccentric exercises vs. stretches

In 2008, Norregaard *et al.*²¹ assessed the effectiveness of a 12-week eccentric exercise and stretching programme. Both the stretching

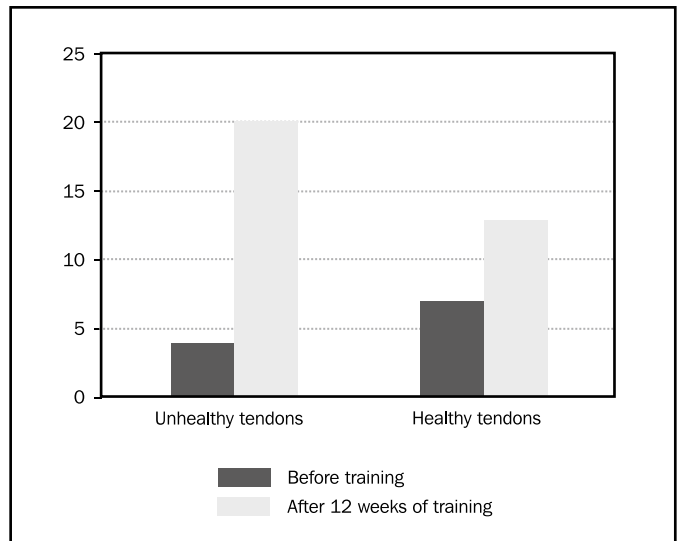
Figure 3. Standard position for carrying out the eccentric exercises¹⁶.



Figure 4. Exercises with declining plane to carry out the eccentric exercises¹⁶.



Figure 5. Eccentric training and the synthesis of type 1 collagen. Rehabilitation via eccentric exercise increases the synthesis of type 1 collagen peritendineum.



group and the eccentric exercises group displayed mild reductions in pain, the eccentric exercise group obtaining the most improvement. Strength was not assessed.

Eccentric exercises vs. night splint

In 2010, Roos *et al.*²² compared the effectiveness of eccentric exercises and night splints over 12 weeks. All the groups displayed substantial improvements in pain. There were no significant differences between the two groups. Strength was not assessed.

Table 2. Results of the studies classed by Article Name, Author, Objectives, Results and Conclusion.

Article Name	Author	Objectives	Results	Conclusion
A pilot study of the eccentric decline squat in the management of painful chronic patellar tendinopathy	Purdam CR, et al ¹⁵	Perform a protocol of treatment for patellar tendinopathy, performing within this protocol different positions of the ankle in dorsi-flexion and compare the progress. Two groups: -Ankle in dorsi-flexion -Ankle in neutral position	No major differences were found in the improvement of tendinopathy with regards to the position of the ankle. Though the location of the injury is not specified.	Indicates that treatment with eccentrics responded well in the treatment of patellar tendinopathy in both groups
Eccentric decline squat protocol offers superior results at 12 months compared with traditional eccentric protocol for patellar tendinopathy in volleyball players	Young MA, et al ¹⁶	Prove the effectiveness of rehabilitation using an eccentric exercise inclined by 25° in the treatment of chronic patellar tendinopathy, compared to the traditional protocol of eccentric exercises. Performed 2 times a day, 3 series of 15 repetitions over 12 weeks.	Doctors may safely use both protocols: both the conservative and eccentric exercises researched in this study have a positive effect on pain, and more importantly, the athlete's capacity to readapt to the physical activity without any problem or aftermath.	Both protocols are effective treatment in the rehabilitation of chronic patellar tendinopathy, with the inclined-plane eccentric exercises proving more effective after 12 months, achieving better VISA marks. Practically, the result is very similar.
Does Eccentric Exercise Reduce Pain and Improve Strength in Physically Active Adults With Symptomatic Lower Extremity Tendinosis? A Systematic Review	Wasielowski J, et al ¹⁷	Compare treatment using eccentric exercises with stretches and concentric exercises.	All the treatments are effective, but the degree of effectiveness of the eccentric exercises is not clear.	Current research indicates that eccentric exercises are an effective way to treat lower-extremity tendinosis, but there is little evidence to suggest that they are better than other forms of therapeutic exercise, such as concentric exercise or stretching. Eccentric exercise may produce better results than some treatments such as wearing a splint, non-thermic ultrasound and friction massage, and be more effective during a break from activity related to the training load.
Treatment of patellar tendinopathy—a systematic review of randomized controlled trials	Maria EH, et al ¹⁴	Review of the different treatment types for patellar tendinopathy	Clear evidence for the use of eccentric training to treat patellar tendinopathy. Moderate evidence for the conservative treatment as an alternative to eccentric training. Moderate evidence suggests that under the intensity of pulsed ultrasound treatment it did not influence the results of the treatment. Limited evidence found for surgery, injection sclerotherapy, and shockwave therapy.	Physical training and in particular eccentric exercises seem to be the treatment of choice for patients suffering from patellar tendinopathy. However, the type of exercise, the frequency, the load and dosage are very important factors that should also be analysed.
The treatment of patellar tendinopathy	Rodriguez-Merchan EC ⁴	The aim of this review is to review the strategies used in treating patellar tendinopathy, distinguishing between conservative and surgical.	Clear evidence eccentric training, moderate improvement with shockwave therapy and different injection treatments (Plasma-rich platelets, polydocanol-sclerosant. steroids, etc.)	Physical training and in particular eccentric training seem to be the treatments of choice. The literature does not clarify which is the most effective surgical technique in recalcitrant cases.
Eccentric exercises; why do they work, what are the problems and how can we improve them?	Rees JD, et al ⁵	Provide evidence for the effectiveness of eccentric exercises.	It specifies that depending on the position level of the injury, a variation is required to the position of the patient to ensure the affected zone is worked specifically. Especially by modifying the dorsiflexion of the ankle and the angle of flexion of the knee.	Evidence does exist regarding the benefits of EE.

(keep going)

Superior results with eccentric compared to concentric quadriceps training in patients with jumper's knee: a prospective randomised study	Jonsson P, et al ³	Compare eccentric exercises to concentric exercises in the treatment of patellar tendinopathy	In the eccentrics group, 9 out of 10 patients were satisfied with the treatment, VAS reduced 73-23 (p, 0.005), and the VISA points rose 41-83 (p, 0.005). In the concentric group, 9.9 patients were not satisfied, and there were no significant differences in the VAS (from 74 to 68, p, 0.34) and VISA points (41-37, p, 0.34).	In conclusion, eccentric but not concentric, the formation of quadriceps on a descending surface seems to reduce pain in jumper's knee.
The role and implementation of eccentric training in athletic rehabilitation: tendinopathy, hamstring strains, and ACL reconstruction	Lorenz D, et al ⁵	Establish the eccentric exercise in rehabilitation.	Evidence of patellar and Achilles tendinopathy rehabilitation using eccentric exercises	In conclusion, the use of eccentric exercises led to a notable improvement in tendinopathies.
Eccentric exercise training: modalities, applications and perspectives	Eve M, et al ⁶	Prove the beneficial properties of EE, applied to the rehabilitation of injuries and explain all the modalities.	Toning the muscles exercised is beneficial. When monitored by a specialist, eccentric exercises can be used to strengthen any weakened muscle following an injury.	Eccentric exercises are beneficial to building muscle strength.
Muscle architecture adaptations to knee extensor eccentric training	Esparza F, et al ⁶	See the changes that occur in the muscular architecture of the knee with extensor eccentric training. Understand the effects of the two eccentric training programmes on the morphology of patellar tendon.	The results are not clear.	With the eccentric exercises there was an increase in muscle thickness, very similar to when concentric exercises are performed. Eccentric training results in hypertrophy of the tendon in patients without patellar tendinopathy. These improvements should be based on the adequate progression of load training, taking particular care with the individual processes needed for each subject.

Eccentric exercises vs. non-thermic ultrasound vs. friction massages

In 2009, Stasinopoulos *et al.*²³ compared three treatment groups that carried out eccentric exercises, non-thermic ultrasound, and transversal friction massage for tendinosypatellar over 8 weeks. There were significant improvements in pain by the end of the treatment.

Discussion

Eccentric exercises have been recommended since the mid-eighties for the rehabilitation of different pathologies and to strengthen muscle. The theory suggests that they reduce pain quicker than stretches, hardening and strengthening the tendinous muscle unit^{8,19,24}. On the other hand, eccentric exercises are considered to promote the alignment of collagen fibres, generating more resistant fibres, stimulating the activity of the fibroblasts and preventing adhesions during the healing stage between the tendon and the adjacent tissues⁵.

Alfredson (1998)^{3,9,16} put forward three possible theories to explain their effectiveness. The first suggests that they create a change in the patient's perception of pain as the exercises are painful. The second suggests the vascularisation that appears in tendinopathy is destroyed and with it the accompanying nerve endings. Finally, the third theory explains that eccentrics increase the tendon's resistance to traction,

producing an elongation of the tendinous muscle unit, with the tendon bearing less tension during movement²⁵⁻²⁷.

Although there are various possible explanations to understand the effectiveness of eccentrics, none have been researched fully²⁸. However, regardless of the underlying mechanisms, they have produced significant improvements in pain reduction and patient satisfaction in between 60-90% of patients²⁹.

The eccentric training model of Alfredson *et al.*, (1998)^{3,9,16} at no point involves a concentric contraction of the affected tendon and makes particular mention of the importance of performing the exercises despite the patient feeling some discomfort, always in the event that this pain does not prevent the exercises from being performed correctly 16. If patients feel no pain or discomfort during the exercise, they may increase the load using a weighted backpack or with weight machines. The programme consisted in a daily training session over 12 weeks and obtained good short and long-term results. It was effective when other conventional treatments such as NSAIDs (non-steroidal anti-inflammatory drugs), rest, a change of footwear, orthosis, and other physical therapies had not worked, whilst the exercise programme had a 90% success rate among patients participating in the study³⁰.

A follow-up study of the patients treated with the eccentric training, performed by the same people around 4 years later, indicated that all were satisfied and returned to their daily and physical activities with no discomfort at all. A relevant piece of data from this study is that the

tendon thickness had reduced and using a sonograph, the tendon structure was more normal³¹⁻³³.

The exercises are performed with the entire load on the affected extremity, with the load progressively increasing. For a sedentary person this load will require a greater effort than for someone that regularly performs exercise. Therefore, despite there being limited evidence that the exercises should be performed with pain, it may be the case that some patients experience more pain than others³⁴, which should be considered an important aspect for the physiotherapist to take into account when applying them^{35,36}.

Another important aspect for the physiotherapist to consider is the possible error-factor on the part of the physiotherapist and the patient, in the number of repetitions, the speed or position. Therefore, from a practical point of view, apart from explaining the exercises clearly, simply and several times, it would also be convenient to accompany this explanation with written information so as to avoid these errors^{37,38}. Another option would be for the physiotherapist to supervise the patient during the first week, twice a day until the patient becomes used to the movements, the exercise and the correct position to perform the exercise, ensuring that when they are performed at home they are done so correctly³⁹⁻⁴¹.

Moreover, according to the Alfredson (1998) protocol^{3,9,16}, the rehabilitation period of 3 months is long, making it easier for the patient to not complete the process. In one of the articles the patients related that they did not complete 50% of the exercises for completion at home, either because of work, time or a lack of motivation³. This is why it should be made clear to the patient that to ensure optimum rehabilitation in the established time period, the patient should complete the exercises recommended in the protocol. One way of ensuring that the patient performs the exercises is through a daily telephone call to monitor the patient, which both from the financial perspective of the physiotherapist, and the perspective of the patient's privacy, is not viable. Even so, it is very important, on the one hand, to motivate the patient to perform them so as to recover quicker: here the physiotherapist could motivate the patient as much as possible⁴²⁻⁴⁴. On the other hand, for a person that regularly performs physical exercise, carrying out these exercises will be less effort than for a sedentary person⁴⁵.

There is also the possibility that, during the treatment protocol, injuries may occur associated with the eccentric exercises. This risk increases among patients that do not perform regular exercises and among patients that do not respect the rest phases⁴⁶.

In this review, the effectiveness of eccentric exercises has been proven for the rehabilitation of chronic patellar tendinopathy, but it is considered that for a more effective and optimum rehabilitation, the recommendation would be to use all the tools available or training possible to recover from the injury.

Within physiotherapy there is the opportunity of combining different treatment types, with the majority being compatible with each other, meaning that the work is not monotonous, and the patient will see improvements each day, observing how the physiotherapist is skilled in approaching this particular injury with different suggestions⁴⁷.

Conclusions

- It has been shown that eccentric exercises are one of the fundamental treatment types in the rehabilitation of patellar tendinopathy, given that they increase the tendon's resistance to traction, producing an elongation of the tendinous muscle unit, thus meaning the tendon bears less tension.
- Some of the physiological effects of the exercises on the tendon have been proven. They are effective in encouraging the formation of tendon collagen fibres, improving its remodelling and requiring less oxygen consumption, greater muscle tension and less energy expenditure.
- No specific exercise protocol was established for patient recommendation.

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¿A cuántos estímulos responde tu corazón?

Vichy Catalan se preocupa por tu salud e investiga sobre el metabolismo del colesterol.

Te quiere



Vichy Catalán y el colesterol

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El agua es un nutriente esencial para el hombre siendo su consumo indispensable para el mantenimiento del estado de hidratación del organismo y garantizar un buen estado de salud.

A nivel de composición nutricional, el agua aporta como únicos nutrientes los elementos minerales, presentes de forma natural en la misma. El tipo de minerales y el contenido de cada uno de ellos resultan característicos de las distintas aguas y por ello pueden caracterizarse. Vichy Catalán es un agua mineral natural carbónica que contiene 1.097 miligramos de sodio por litro, en cuya composición destacan además otros oligominerales como: bicarbonatos, sulfatos, cloruros y potasio. La biodisponibilidad de los electrolitos en esta agua es muy alta y por ello se considera que por un lado contribuye a la ingesta total diaria de estos nutrientes (FNB, 2004) y por otro que puede desempeñar un papel en la prevención de las enfermedades cardiovasculares. En esta línea de evidencia, recientes investigaciones han demostrado que el consumo de 1 litro al día de agua mineral bicarbonatada como Vichy Catalán durante 8 semanas reduce el riesgo cardiovascular en mujeres postmenopáusicas y en adultos jóvenes hipercolesterolémicos, reduciendo tanto las cifras de colesterol-LDL como el ratio de colesterol total/colesterol HDL. A nivel de cifras tensionales, aún siendo el contenido en sodio del agua administrada superior a 1 gramo por litro, no se observa afectación en las cifras tensionales entre las mujeres postmenopáusicas e incluso se reducen las cifras de tensión arterial sistólica entre los adultos jóvenes (Schoppen S, 2004 y Perez-Granados, 2010).

Por otro lado, también se ha establecido la relación entre el consumo de 0,5 L/día de agua Vichy Catalán (agua mineral bicarbonatada) con una comida estándar y la reducción de la lipemia postprandial en mujeres postmenopáusicas también sanas, respecto al consumo de agua mineral con menor contenido en minerales (Schoppen, 2005). Hallazgo de gran interés, ya que se sabe que el metabolismo lipídico postprandial juega un papel muy importante en la salud, ya puede ser un factor de riesgo en el desarrollo de aterogénesis y de las enfermedades cardiovasculares.

Ambos resultados obtenidos en estos estudios demuestran por tanto la influencia que los hábitos alimentarios y, en concreto, la hidratación y el tipo de agua de bebida, pueden tener en la prevención de las enfermedades cardiovasculares.

El efecto preventivo demostrado en estos estudios que ejerce el consumo de *Vichy Catalán*, tanto en el metabolismo del colesterol como en el de las lipoproteínas, parece ser debido a la composición característica de esta agua carbónica que la diferencia del resto de aguas comerciales, por su alto contenido en sodio, potasio, bicarbonato, sílice e incluso litio.

Además de los efectos preventivos a nivel cardiovascular anteriormente descritos, otras investigaciones recientes como la realizada por Toxqui (2012) estudian otros posibles efectos del consumo de agua bicarbonatada y la salud cardiovascular. En

este caso, se estudian los efectos postprandiales de la ingesta de agua bicarbonatada sódica consumida con una comida estándar sobre los niveles séricos de triglicéridos (TG), de colesteroquinina y a nivel de la contracción y el vaciado de la vesícula biliar. Así se demuestra que en adultos jóvenes de 18 a 40 años de ambos sexos el consumo de 0,5 L/día de agua bicarbonatada sódica junto con una comida estándar (rica en grasas: 62% de lípidos, 30% de hidratos de carbono y 8% de proteínas) induce a menores niveles de triglicéridos y colesteroquinina postprandiales, elementos con claro impacto sobre la salud cardiovascular.

Los niveles de triglicéridos postprandiales son un reflejo del metabolismo lipídico postprandial que tiene un papel fundamental en el desarrollo de las enfermedades cardiovasculares, ya que un anormal transporte y metabolismo de las lipoproteínas LDL (ricas en TG) en el periodo postprandial se ha relacionado con la aterogénesis. Y, por lo tanto, como se demuestra en este estudio, una reducción en las lipoproteínas ricas en TG podría limitar la progresión de la arteriosclerosis.

La colesteroquinina por su parte es una hormona que estimula la contracción de la vesícula biliar que segrega las sales biliares encargadas de la solubilización y absorción de las grasas. Por tanto, una reducción en los niveles de colesteroquinina postprandiales supone a su vez la reducción de la contracción y vaciamiento de la vesícula biliar y en consecuencia una menor absorción intestinal de lípidos.

Por lo tanto, y a modo de conclusión, demostrado el efecto positivo que el consumo de agua bicarbonatada carbónica tiene sobre la salud, Vichy Catalán podría ser utilizado como un elemento a incluir en la alimentación habitual de la población sana para conseguir reducir el riesgo cardiovascular.

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Ama tu vida

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