

SPORT READAPTATION AND RETURN TO PLAY IN HIGH PERFORMANCE: FROM LABORATORY TO THE FIELD

READAPTACION Y RETORNO DEPORTIVO EN EL ALTO RENDIMIENTO: DEL LABORATORIO AL CAMPO DE JUEGO: UNA REVISION DE LA LITERATURA

Alfonso Mantilla, José Iván¹FDA

¹ Physiotherapist Universidad del Rosario with emphasis on physical activity, sports and sports readaptation, Colombia, Josealfonso25@hotmail.com.

Responsibilities (A Research design; B Data collector; C Editor of the paper; D Statistical processing; E Financial support; F Original idea and coordinator of the entire research)

Received on 19 of September of 2022

Accepted on 28 of November of 2022

DOI: 10.24310/riccafd.2022.v11i3.15381

Correspondence:

Jose Iván Alfonso Mantilla, Josealfonso25@hotmail.com

ABSTRACT

Introduction Currently, sports readaptation is known as a dynamic process at the structural and functional level of elements of human body movement such as physical qualities around strength, endurance, speed, power, joint and muscle synergies, efficiency and effectiveness of movement and potentiation of functional skills for high performance sport after a sports injury **Methodology** literature review based on PRISMA criteria, where the search was performed in major databases such as: Pubmed, Ebsco, Medline, Scopus, Science Direct with the following DeCS terms: Return to sport, Performance, sports, Return to training, Return to play, Rehabilitation, sports language of evidence English, Spanish, Portuguese, Catalan and French **Results** it was possible to obtain information from 74 articles where it was established that the sports readaptation process is based on specific pillars such as movement, functional patterns, load control, monitoring, and follow-up criteria by phase that allow developing a successful return to high sport performance. **Conclusion**, sports readaptation is a process that allows making decisions based on a systematized development of the sports return process that generates the

evolution of the concept of sports readaptation as an essential pillar in the work of high performance sport in any sport discipline.

KEY WORDS: return to sport, performance, sports, return to training, return to play, rehabilitation.

RESUMEN

Introducción En la actualidad, la readaptación deportiva se conoce como un proceso dinámico a nivel estructural y funcional de elementos del movimiento corporal humano tales como cualidades físicas alrededor de la fuerza, resistencia, velocidad, potencia, sinergias articulares y musculares, eficiencia y eficacia del movimiento y potencialización de habilidades funcionales para el deporte de alto rendimiento después de una lesión deportiva **Metodología** revisión de la literatura basada en los criterios PRISMA, donde se realizó la búsqueda en las principales bases de datos tales como: Pubmed, Ebsco, Medline, Scopus, Science Direct con los siguientes terminos DeCS: Return to sport, Performance, sports, Return to training, Return to play, Rehabilitation, sports idioma de evidencia inglés, español, portugués, catalán y francés **Resultados** se pudo obtener la información de 74 artículos donde se estableció que el proceso de readaptación deportiva se basa en pilares específicos tales como movimiento, patrones funcionales, control de carga, monitorización, y criterios de seguimiento por fase que permiten desarrollar un retorno exitoso al alto rendimiento deportivo. **Conclusión** la readaptación deportiva es un proceso que permite tomar decisiones basadas en un desarrollo sistematizado del proceso de retorno deportivo que genera la evolución del concepto de readaptador deportivo como un pilar esencial en el trabajo del deporte de alto rendimiento en cualquier disciplina deportiva.

PALABRAS CLAVE: retorno al deporte, rendimiento, deporte, retorno al entrenamiento, retorno al juego, rehabilitación

INTRODUCTION

The practice of sports disciplines at performance level allows the development of physical qualities, social interaction, detection of sports talent and generation of high performance athletes to obtain national and international titles(1-3). Every sporting discipline, regardless of its modality, is of high physical demand for the cardiovascular, neuromuscular and motor systems where movement patterns specific to the sport are identified such as accelerations, decelerations, changes of direction, sprints, jumps, turns, brakes, which are quantified by means of technological devices recording the levels of external and internal load characterizing the physiological demands during training and competition(4-6). Sports disciplines, being categorized as an activity of high metabolic and physiological demand for those who practice them, require preparation in all areas of human body movement such as strength, agility, speed, stability, flexibility, neuromuscular control(7, 8). These skills are the pillars of the development of the functional state of the professional athlete in the development of technical-tactical activities specific to the sport applied to a specific system and intensity of play(9, 10).

Sports injuries in all sports disciplines can occur during training or competition and can be traumatic or non-traumatic and by contact or non-contact due to different internal and external factors that condition the responses of the athletes, where negative alterations are produced such as the unavailability of players due to injury, economic costs for the club (11-14). The rehabilitation of sports injuries is a dynamic process based on movement pillars where a staircase is reconstructed, in which each step is based on specific skills of human body movement, skills composed for the sport to develop a competitive athlete again and that has advanced in a process of functional return to the activity guided in standardized pillars of follow-up and monitoring generating profiles of performance, rehabilitation and sports readaptation (15-19).

From the moment a sports injury occurs, a diagnostic criterion is established, given in the first place by sports medicine, where an injury at a structural level must be established and which has consequences at a functional

level and therefore will have a specific prognosis. This process is a dynamic moment where the injury must be understood as a component that has multiple scenarios and that will generate consequences for the athlete, the physiotherapist will be in charge together with the sports doctor in establishing the diagnosis and functional prognosis of the athlete to guide the rehabilitation process(20-22).

The recovery process of a sports injury is a gap where the athlete faces different challenges from the physiological, physical, social and psychological part that is largely accompanied by the entire team in which the player develops as technical director, technical assistant, physician, physiotherapist, nutritionist, physical trainer, psychologist where they face different contexts at the psychosocial level of the athlete that can condition the response to the process, where communication becomes vital in the process and the achievement of objectives in the successful path of sporting return(23-26).

Sports readaptation is defined as a dynamic process after rehabilitation where different areas of expertise intervene with the objective of returning an athlete to the maximum level of functionality after a sports injury, combining different concepts such as load control, field functionality, monitoring and periodization of physical performance(27, 28). This readaptation process is based on different aspects such as a correct diagnosis, variability of the process, control and management of sessions with workloads arrangement, risk management and injury modifiers to work towards the goal of minimizing the risk of re-injury and return to the maximum functional potential of the athlete(29). The aim of this article is to review the literature and an approach to the process of sports readaptation in high performance sports.

MATERIAL AND METHODS

Type of study

A systematic review of the literature was carried out based on the PRISMA criteria where the search was made in the main databases such as: Pubmed, Ebsco, Medline, Scopus, Science Direct, using the documentary technique to collect the information using specific files, evaluating the quality of the articles consulted with the PEDRO scale.

PICO strategy

The search for information was established based on the following criteria

P: Athletes of any sport discipline

I: Sports rehabilitation of specific injuries at muscular, articular, ligament, tendon and tendon level.

C: Completion of the rehabilitation process without sporting return.

O: Stages of sports rehabilitation, types of exercises, load control.

Inclusion and exclusion criteria

Inclusion: Literature contemplated from the year 2018-2022, literature that contemplated the following DeCS terms: Return to Sport, Performance, sports, Return to training, Return to play, Rehabilitation, sports language of evidence English, Spanish, Portuguese, Catalan and French, studies that took into account sports readaptation isolated from the rehabilitation process,

Exclusion: Studies that were not available for download, studies that did not comply with the established search year, studies that contemplated sports readaptation processes.

Search for information

The search for evidence was carried out using the combination of key concepts such as: [Return to Sport] AND [Return to training]; [Return to training] AND [sports]; [return to training] AND [Return to play]; [Return to training] AND [Sports]; [Return to play] AND [sports]; [return to training] AND [Performance]; [rehabilitation] AND [return to training]; [return to training] AND [Return to sport] AND [Sports].

RESULTS

Selection process

The selection was carried out based on the criteria provided, where the combined results of the search yielded (150) articles, with their subsequent evaluation based on abstracts (134) and their elimination due to duplication (122), and with the evaluation by inclusion and exclusion criteria, a total of (74) were obtained. Figure 1 shows the evidence extraction flowchart.

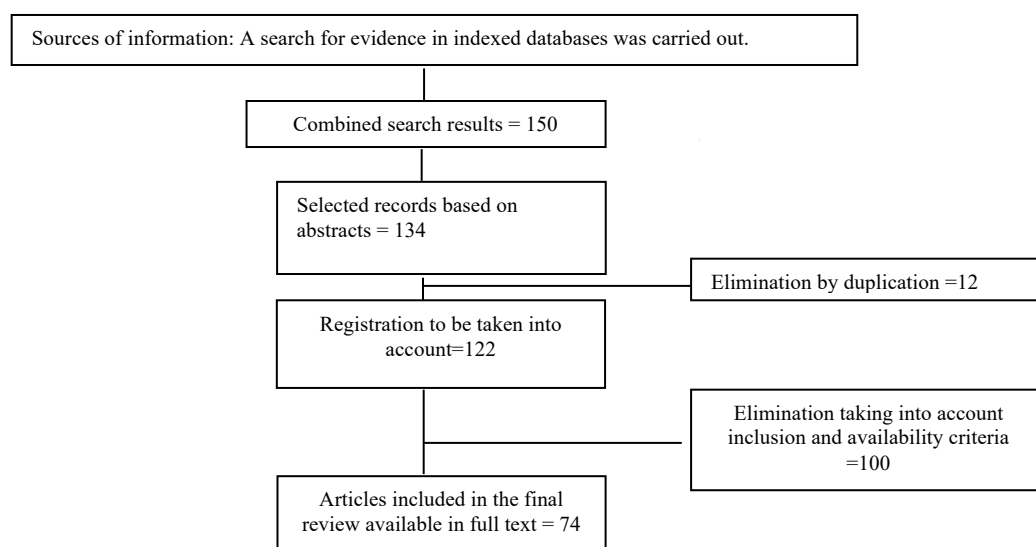


Figure 1 (Evidence extraction flowchart)

Within the evidence consulted, in the first instance it could be determined that a readaptation of specific movement patterns of the sport discipline such as accelerations, decelerations, changes of direction, sprints, jumps, turns, which are within a structured macrocycle with structural, coadjuvant and optimizing factors that adapt the maximum functional capacity of the athlete (4-6, 17, 18, 30, 31) should be performed. Figure 2 shows the skills in the sports readaptation process.

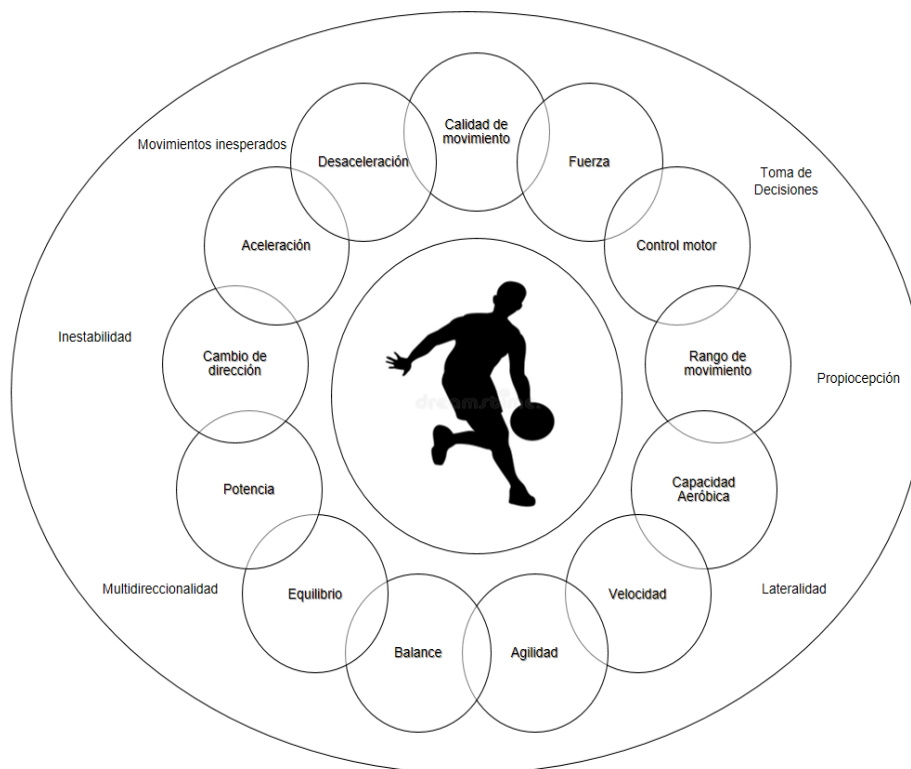


Figure 2 (Skills in the process of sports readaptation). Source of own elaboration 2022

Secondly, with the evolution of knowledge and scientific evidence, in the last decade the concept of sports readaptor has been evidenced, which is a professional with skills in sports injuries, rehabilitation, anatomy, exercise prescription, planning which provides the athlete with an enabling environment of confidence and flexibility for the process of sports return(27). At present there is no defined profession that performs this activity, so it is performed in an interdisciplinary manner among all team members, however, work should be done for the professionalization of this role within educational institutions(19, 27). Figure 3 shows the participants in the sports rehabilitation process.

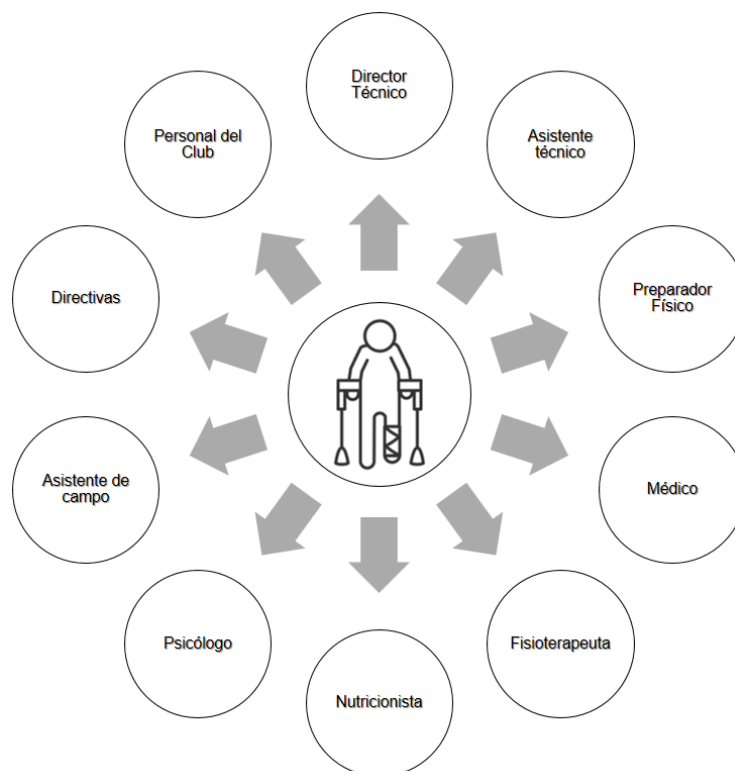


Figure 3 (Participants in the sports readaptation process). Source of own elaboration 2022

Currently, the stairway to sport return is known as a dynamic process where the following concepts interact such as Return to play as the acronym to characterize the process of sport readaptation(32). This process starts from the characterization of reconstructing the main movement skills to the functionality in the sport discipline. In the first instance, it starts with returning to the quality of movement to the athlete establishing the importance of working by joints and generating a correct synergy between the movement and the structural components at anatomical level working from the concept of specific function to work composite movement skills given by biomechanics(33-35). Secondly, when there is adequate movement control, the development of physical capacities will be the second pillar of the process where the objective is to maximize strength, endurance, speed, agility, cardiorespiratory capacity, power, respecting the healing periods of the injury and monitoring the evolution of the process(26, 36). Thirdly, at the end of the laboratory process, field rehabilitation begins based on the transition of the recovery process to reconstruct the movement of the skills of

the sports discipline such as linear movement, multidirectional movements, lateral movements, landing, take-off, braking, shock, perturbations, technical skills in combination and simulation of real actions until reaching moments of controlled sports practice by the readaptor and leading to the return to training loads imposed with the group(15, 16, 37). The following concepts are presented to take into account within the sports readaptation process:

Return to Run (RtRun)

The ability to respond to a kinetic and kinetic biomechanical pattern that requires a full range of motion without pain or joint effusion to generate sensations in the player after rehabilitation by characterizing a main movement pattern(23, 38, 39).

Return to Participation (RtParticipation)

Readaptation pattern where the athlete is physically active. However, he/she is not prepared to tolerate the physical, physiological and metabolic demands of training and competition(19, 32, 40-42).

Return to training (Rt Training)

Pattern where the athlete actively participates in training with the team under the supervision of the work group and performing an internal and external load control, establishing a monitoring methodology and specific profile(19, 43-45).

Return to Sport (Rtsport)

The athlete returns to sport after the analysis of the monitored profile during the rehabilitation and readaptation to performance process where parameters of total sport discharge are established at a level where he/she can be considered by the team technician for competition(19, 43, 46, 47).

Return to Performance (RtPerformance)

Stage in which the formal process of sports readaptation is completed, where the player continues to work with the team, training normally and the optimal

performance after the injury will be determined by the athlete (19, 41, 48, 49). With the evidence consulted, Figure 4 shows the sports readaptation process that could be established with the evidence consulted in this review.

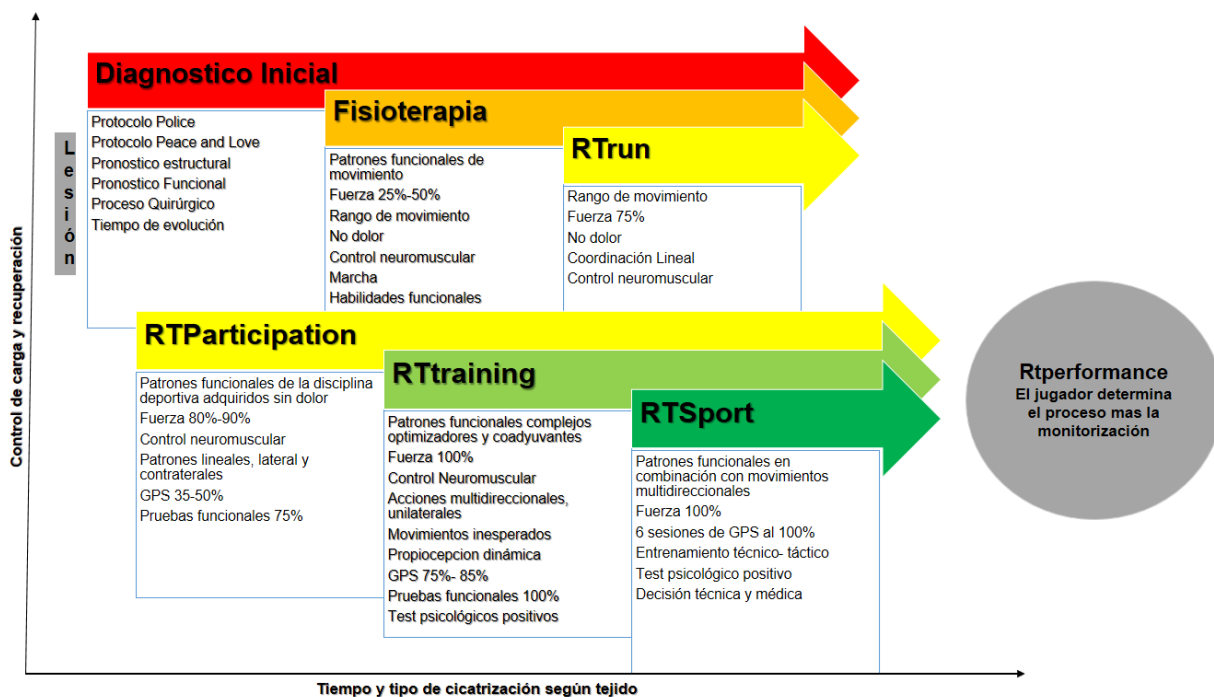


Figure 4 (Sports return process). Source of own elaboration 2022

Currently, technology has allowed high performance sport to standardize various processes such as rehabilitation, training and readaptation(50, 51). Within the readaptation, the athlete must have parameters of movement quality, strength, neuromuscular control, stability that are measured in the period of time between field rehabilitation and sports readaptation where among the main tools used are: Linear and rotary encoder, Isometric devices, isokinetic evaluation machines, ergo-spirometry, force plates, Nordbord, Groinbar, surface electromyography, GPS, biomechanical evaluation and field testing where these devices and tests yield quantitative data that allow decisions to be made from a statistical profile and monitor the process constantly allowing the identification of muscle imbalances, indices of relationship between muscles, fatigue levels, maximum oxygen consumption at performance thresholds, neuromuscular

activation and its relationship with the injury specifically(52-64). Figure 5 shows the monitoring tools for the sports readaptation process.

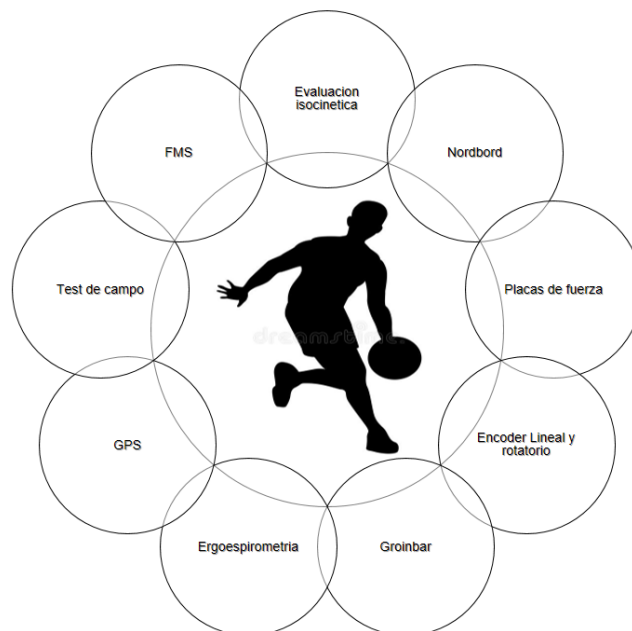


Figure 5 (Monitoring of the sports readaptation process). Source of own elaboration 2022

The readaptation of sport gestures in the field is one of the most important pillars in the process of sport return where functional exercises should be performed to stimulate different types of gestures such as linear patterns, lateral patterns, diagonal patterns, brakes, decelerations, accelerations, unipodal gestures, bilateral gestures, unipodal stability, stability to unexpected events, multidirectional movements, stability, balance, jumping, decision making based on sport gestures(15-17). Additionally, the work is done to train the movement to be efficient before functional movements of the sport that allow the athlete to perform specific gestures with greater mobility, strength, range of motion working the efficiency of movement in specific patterns and planes of movement where it is of vital importance that every movement that is worked in sports rehabilitation is functional, monitored, corrected and potentiated(34, 65). The monitoring and periodization of the load is a fundamental point of the process where the variables

of the training are controlled to prevent the appearance of adjacent injuries, pain, overtraining where by means of devices such as GPS, variables such as accelerations, decelerations, sprint, distance, load, jump, speed are controlled in a real way in the field where it becomes an indication for the entire medical and readaptation body to follow the process of the player and lead him to success in the process of sporting return(54, 66).

DISCUSSION

Sports readaptation is considered an art in relating variables such as external, internal, psychological, social and personal load of an athlete where training parameters plus technical-tactical variables that can be controlled within a model of maximum to minimum risk control should be taken into account to establish the criteria for progression by specific phase(54, 67). To exemplify, specific work should be performed for the position of the athlete involving tasks in a circuit that combines variables such as intensity, tactical and technical orders, real game actions controlling the load and identifying the profile by specific work given by game actions under the technical-tactical work that allow determining specific profiles by game situation making assessments by ranges of normality by game action(68-70).

When the whole monitoring process is carried out, the chronic load adaptation process will begin, where the player must return to optimal load levels, starting from basal levels to competition levels, where a control of the load peaks per specific readaptation session is initiated until managing intensity and load levels close to those of a real competition to prepare the player for all the scenarios that may occur again in the field of play under specific actions in low, moderate and chronic intensity demands(71, 72). It is of vital importance that the player develops guided training concepts that lead him to develop physical capacities adapted to the level of competition and to develop an athlete adapted to chronic loads and evolution windows at specific training intensity and competition(44, 73).

When the whole unified process of individualized sports readaptation is carried out, the player begins to be integrated to work with the main group where he/she starts to be integrated under the structured model where all the bases and structures of the athlete are taken into account such as bioenergetic, coordinative, cognitive, socio-affective, emotional and mental integrated to the system and tactical model of training where the variation of work and load becomes the most important pillar of progression for the athlete(19, 30). Secondly, the player must be integrated to optimizing and coadjuvant works where there is a combination of basic, moderate and complex functional gestures of the sport with variations with different types of elements to stimulate real game actions and situations where the player has to make decisions regarding space, time and element within a specific game plane with gestures such as brakes, accelerations, jumps, stability, driving, displacements, pushes, tractions, decelerations, changes of direction (19, 31, 74).

The readaptation process is complex and requires evidence-based medicine and practice combining knowledge with specific cases and scenarios that only high performance sport offers within the real world of sports rehabilitation where each athlete is a complex system of interaction at the structural and functional level. More research should be developed in relation to sports rehabilitation in order to generate standardized follow-up processes that allow the creation of specific profiles. It is therefore of vital importance the research in the sports field by all professionals in the areas of health and performance.

CONCLUSIONS

Sports rehabilitation is a cyclical, systemic, integrated and personalized process with specific pillars such as return stages, load control, monitoring and periodization that generate quantitative data with reference values in high performance athletes that allow making decisions based on a systematized process generating the evolution of the concept of the sports trainer as an essential pillar in the work in high performance sport in any sport discipline.

BIBLIOGRAPHY

1. Narazaki K, Berg K, Stergiou N, Chen B. Physiological demands of competitive basketball. *Scandinavian journal of medicine & science in sports*. 2009;19(3):425-32.
2. McGee C, Hwu M, Nicholson LL, Ho KKN. More Than a Game: Musculoskeletal Injuries and a Key Role for the Physical Therapist in Esports. *J Orthop Sports Phys Ther*. 2021;51(9):415-7.
3. Williams AM, Ford PR, Drust B. Talent identification and development in soccer since the millennium. *J Sports Sci*. 2020;38(11-12):1199-210.
4. Montgomery PG, Pyne DB, Minahan CL. The physical and physiological demands of basketball training and competition. *International journal of sports physiology and performance*. 2010;5(1):75-86.
5. Stojanović E, Stojiljković N, Scanlan AT, Dalbo VJ, Berkelmans DM, Milanović Z. The activity demands and physiological responses encountered during basketball match-play: a systematic review. *Sports Medicine*. 2018;48(1):111-35.
6. Gottlieb R, Shalom A, Calleja-Gonzalez J. Physiology of Basketball–Field Tests. Review Article. *Journal of Human Kinetics*. 2021;77(1):159-67.
7. Torres-Unda J, Zarrazquin I, Gil J, Ruiz F, Irazusta A, Kortajarena M, et al. Anthropometric, physiological and maturational characteristics in selected elite and non-elite male adolescent basketball players. *Journal of sports sciences*. 2013;31(2):196-203.
8. Boone J, Bourgois J. Morphological and physiological profile of elite basketball players in Belgium. *International Journal of Sports Physiology and Performance*. 2013;8(6):630-8.
9. Bazanov B. Integrative approach of the technical and tactical aspects in basketball coaching. *Abstract Tallinn University Dissertations on Social Sciences*. 2007;30:1736-3675.
10. Mateus N, Santos S, Vaz L, Gomes I, Leite N. The effect of a physical literacy and differential learning program in motor, technical and tactical basketball skills. *Revista de psicología del deporte*. 2015;24(1):73-6.
11. Hägglund M, Waldén M, Magnusson H, Kristenson K, Bengtsson H, Ekstrand J. Injuries affect team performance negatively in professional football: an 11-year follow-up of the UEFA Champions League injury study. *Br J Sports Med*. 2013;47(12):738-42.
12. Eliakim E, Morgulev E, Lidor R, Meckel Y. Estimation of injury costs: financial damage of English Premier League teams' underachievement due to injuries. *BMJ Open Sport Exerc Med*. 2020;6(1):e000675.
13. Secrist ES, Bhat SB, Dodson CC. The Financial and Professional Impact of Anterior Cruciate Ligament Injuries in National Football League Athletes. *Orthop J Sports Med*. 2016;4(8):2325967116663921.
14. Ferioli D, La Torre A, Tibiletti E, Dotto A, Rampinini E. Determining the relationship between load markers and non-contact injuries during the competitive season among professional and semi-professional basketball players. *Res Sports Med*. 2021;29(3):265-76.
15. Buckthorpe M, Della Villa F, Della Villa S, Roi GS. On-field Rehabilitation Part 1: 4 Pillars of High-Quality On-field Rehabilitation Are Restoring Movement

Quality, Physical Conditioning, Restoring Sport-Specific Skills, and Progressively Developing Chronic Training Load. *J Orthop Sports Phys Ther.* 2019;49(8):565-9.

16. Buckthorpe M, Della Villa F, Della Villa S, Roi GS. On-field Rehabilitation Part 2: A 5-Stage Program for the Soccer Player Focused on Linear Movements, Multidirectional Movements, Soccer-Specific Skills, Soccer-Specific Movements, and Modified Practice. *J Orthop Sports Phys Ther.* 2019;49(8):570-5.

17. Tous-Fajardo J, Gonzalo-Skok O, Arjol-Serrano JL, Tesch P. Enhancing Change-of-Direction Speed in Soccer Players by Functional Inertial Eccentric Overload and Vibration Training. *Int J Sports Physiol Perform.* 2016;11(1):66-73.

18. Gonzalo-Skok O, Tous-Fajardo J, Valero-Campo C, Berzosa C, Bataller AV, Arjol-Serrano JL, et al. Eccentric-Overload Training in Team-Sport Functional Performance: Constant Bilateral Vertical Versus Variable Unilateral Multidirectional Movements. *Int J Sports Physiol Perform.* 2017;12(7):951-8.

19. Alfonso Mantilla JI. Readaptación Deportiva, de la Lesión al Rendimiento: Factores Clave en la Escalera al Éxito. *Revista Kronos.* 2022;21(1).

20. Sabino GS, Coelho CM, Sampaio RF. The use of the International Classification of Functioning, Disability and Health in the physical therapy assessment of individuals with musculoskeletal disorders of the lower limbs and lumbar region. *Acta Fisiátrica.* 2008;15(1):24-30.

21. Mulligan EP, DeVahl J. SPORTS PHYSICAL THERAPY CURRICULA IN PHYSICAL THERAPIST PROFESSIONAL DEGREE PROGRAMS. *Int J Sports Phys Ther.* 2017;12(5):787-97.

22. Mulligan EP, Rauh MJ, Heiderscheit B, Jenkins WL. Sports Physical Therapy Education in the United States: Where Do We Go from Here? A Survey of American Academy of Sports Physical Therapy Members. *Journal of allied health.* 2020;49(2):79E-87E.

23. Ekstrand J, Lundqvist D, Davison M, D'Hooghe M, Pensgaard AM. Communication quality between the medical team and the head coach/manager is associated with injury burden and player availability in elite football clubs. *Br J Sports Med.* 2019;53(5):304-8.

24. van der Horst N, Backx F, Goedhart EA, Huisstede BM. Return to play after hamstring injuries in football (soccer): a worldwide Delphi procedure regarding definition, medical criteria and decision-making. *Br J Sports Med.* 2017;51(22):1583-91.

25. Dunlop G, Ardern CL, Andersen TE, Lewin C, Dupont G, Ashworth B, et al. Return-to-Play Practices Following Hamstring Injury: A Worldwide Survey of 131 Premier League Football Teams. *Sports Med.* 2020;50(4):829-40.

26. Hoover DL, VanWye WR, Judge LW. Periodization and physical therapy: Bridging the gap between training and rehabilitation. *Physical therapy in Sport.* 2016;18:1-20.

27. Caparrós T, Pujol M, Salas C. Pautas generales en el proceso de readaptación al entrenamiento después de una lesión deportiva. *Apuntes Medicina de l' Esport (Castellano).* 2017;52(196):167-72.

28. Taberner M, van Dyk N, Allen T, Jain N, Richter C, Drust B, et al. Physical preparation and return to performance of an elite female football player following ACL reconstruction: a journey to the FIFA Women's World Cup. *BMJ Open Sport Exerc Med.* 2020;6(1):e000843.

29. Pruna R. Return to play: ¿ Hacia dónde vamos? Esto no es un juego de adivinanzas. *Apunts: Medicina de l'esport*. 2016;51(191):109-12.
30. Tarragó J, Seirul-lo F, Cos F. Training in team sports: structured training in the FCB. *Apunts Educació Física i Esports*. 2019(137):103-14.
31. Gómez A, Roqueta E, Tarragó JR, Seirul F, Cos F. Entrenament en esports d'equip: l'entrenament coadjuvant en el FCB. *Apunts Educació física i esports*. 2019;4(138):13-25.
32. Ardern CL, Glasgow P, Schneiders A, Witvrouw E, Clarsen B, Cools A, et al. 2016 Consensus statement on return to sport from the First World Congress in Sports Physical Therapy, Bern. *Br J Sports Med*. 2016;50(14):853-64.
33. Boyle M. Functional training for sports: superior conditioning for today's athlete: *Human Kinetics*; 2004.
34. Cook G, Burton L, Hoogenboom BJ, Voight M. Functional movement screening: the use of fundamental movements as an assessment of function - part 1. *Int J Sports Phys Ther*. 2014;9(3):396-409.
35. Cook G, Burton L, Hoogenboom BJ, Voight M. Functional movement screening: the use of fundamental movements as an assessment of function-part 2. *Int J Sports Phys Ther*. 2014;9(4):549-63.
36. Pieters D, Wezenbeek E, Schuermans J, Witvrouw E. Return to Play After a Hamstring Strain Injury: It is Time to Consider Natural Healing. *Sports Med*. 2021;51(10):2067-77.
37. Ardern CL, Bizzini M, Bahr R. It is time for consensus on return to play after injury: five key questions. *Br J Sports Med*. 50. England2016. p. 506-8.
38. Rambaud AJM, Semay B, Samozino P, Morin JB, Testa R, Philippot R, et al. Criteria for Return to Sport after Anterior Cruciate Ligament reconstruction with lower reinjury risk (CR'STAL study): protocol for a prospective observational study in France. *BMJ Open*. 2017;7(6):e015087.
39. Liem BC, Truswell HJ, Harrast MA. Rehabilitation and return to running after lower limb stress fractures. *Curr Sports Med Rep*. 2013;12(3):200-7.
40. D'Onofrio R, Padasala M, Apostolopoulos N, Bhatt J, Febbrari L, Bjelica B, et al. The return to sport after muscular injury of the " Hamstring". *A Systemic Review*. *Ita J Sports Reh Po*. 2021;8(17):2.
41. Morrison S, Ward P, duManoir GR. ENERGY SYSTEM DEVELOPMENT AND LOAD MANAGEMENT THROUGH THE REHABILITATION AND RETURN TO PLAY PROCESS. *Int J Sports Phys Ther*. 2017;12(4):697-710.
42. Rebelo-Marques A, Andrade R, Pereira R, Espregueira-Mendes J. Return to Play (RTP). *The Sports Medicine Physician: Springer*; 2019. p. 149-69.
43. Doege J, Ayres JM, Mackay MJ, Tarakemeh A, Brown SM, Vopat BG, et al. Defining Return to Sport: A Systematic Review. *Orthop J Sports Med*. 2021;9(7):23259671211009589.
44. Blanch P, Gabbett TJ. Has the athlete trained enough to return to play safely? The acute:chronic workload ratio permits clinicians to quantify a player's risk of subsequent injury. *Br J Sports Med*. 2016;50(8):471-5.
45. Bisciotti GN, Volpi P, Alberti G, Aprato A, Artina M, Auci A, et al. Italian consensus statement (2020) on return to play after lower limb muscle injury in football (soccer). *BMJ Open Sport Exerc Med*. 2019;5(1):e000505.

46. Gabbett TJ. How Much? How Fast? How Soon? Three Simple Concepts for Progressing Training Loads to Minimize Injury Risk and Enhance Performance. *J Orthop Sports Phys Ther.* 2020;50(10):570-3.
47. Wilk KE, Arrigo CA. Rehabilitation Principles of the Anterior Cruciate Ligament Reconstructed Knee: Twelve Steps for Successful Progression and Return to Play. *Clin Sports Med.* 2017;36(1):189-232.
48. D'Onofrio Rosario PM, Vincenzo M, Bojan B, Aksović N. The final stage (late) of sport rehabilitation: critical analysis of quality of movement and injury risk factors during return to sport, Ita. *J Sports Reh Po.* 2021;8(Suppl 1):13-30.
49. Mendiguchia J, Martinez-Ruiz E, Edouard P, Morin JB, Martinez-Martinez F, Idoate F, et al. A Multifactorial, Criteria-based Progressive Algorithm for Hamstring Injury Treatment. *Med Sci Sports Exerc.* 2017;49(7):1482-92.
50. Whelan DF, O'Reilly MA, Ward TE, Delahunt E, Caulfield B. Technology in rehabilitation: evaluating the single leg squat exercise with wearable inertial measurement units. *Methods of information in medicine.* 2017;56(02):88-94.
51. Núñez FJ, Santalla A, Carrasquilla I, Asian JA, Reina JI, Suarez-Arrones LJ. The effects of unilateral and bilateral eccentric overload training on hypertrophy, muscle power and COD performance, and its determinants, in team sport players. *PloS one.* 2018;13(3):e0193841.
52. Lozano D, Lampre M, Díez A, Gonzalo-Skok O, Jaén-Carrillo D, Castillo D, et al. Global Positioning System Analysis of Physical Demands in Small and Large-Sided Games with Floaters and Official Matches in the Process of Return to Play in High Level Soccer Players. *Sensors (Basel).* 2020;20(22).
53. Reid LC, Cowman JR, Green BS, Coughlan GF. Return to play in elite rugby union: application of global positioning system technology in return-to-running programs. *J Sport Rehabil.* 2013;22(2):122-9.
54. Taberner M, Allen T, Cohen DD. Progressing rehabilitation after injury: consider the 'control-chaos continuum'. *Br J Sports Med.* 532019. p. 1132-6.
55. Buchheit M, Cholley Y, Nagel M, Poulos N. The Effect of Body Mass on Eccentric Knee-Flexor Strength Assessed With an Instrumented Nordic Hamstring Device (Nordbord) in Football Players. *Int J Sports Physiol Perform.* 2016;11(6):721-6.
56. Opar DA, Piatkowski T, Williams MD, Shield AJ. A novel device using the Nordic hamstring exercise to assess eccentric knee flexor strength: a reliability and retrospective injury study. *J Orthop Sports Phys Ther.* 2013;43(9):636-40.
57. Bourne MN, Williams M, Jackson J, Williams KL, Timmins RG, Pizzari T. Preseason Hip/Groin Strength and HAGOS Scores Are Associated With Subsequent Injury in Professional Male Soccer Players. *J Orthop Sports Phys Ther.* 2020;50(5):234-42.
58. Baranauskas M, Jablonskienė V, Abaravičius JA, Stukas R. Cardiorespiratory Fitness and Diet Quality Profile of the Lithuanian Team of Deaf Women's Basketball Players. *Int J Environ Res Public Health.* 2020;17(18).
59. Harper DJ, Cohen DD, Carling C, Kiely J. Can Countermovement Jump Neuromuscular Performance Qualities Differentiate Maximal Horizontal Deceleration Ability in Team Sport Athletes? *Sports (Basel).* 2020;8(6).
60. Constantine E, Taberner M, Richter C, Willett M, Cohen DD. Isometric Posterior Chain Peak Force Recovery Response Following Match-Play in Elite Youth Soccer Players: Associations with Relative Posterior Chain Strength. *Sports (Basel).* 2019;7(10).

61. Hickey JT, Timmins RG, Maniar N, Williams MD, Opar DA. Criteria for Progressing Rehabilitation and Determining Return-to-Play Clearance Following Hamstring Strain Injury: A Systematic Review. *Sports Med.* 2017;47(7):1375-87.
62. Paul DJ, Nassis GP. Testing strength and power in soccer players: the application of conventional and traditional methods of assessment. *J Strength Cond Res.* 2015;29(6):1748-58.
63. Bardella P, Carrasquilla García I, Pozzo M, Tous-Fajardo J, Saez de Villareal E, Suarez-Arrones L. Optimal sampling frequency in recording of resistance training exercises. *Sports Biomech.* 2017;16(1):102-14.
64. Blasimann A, Koenig I, Baert I, Baur H, Vissers D. Which assessments are used to analyze neuromuscular control by electromyography after an anterior cruciate ligament injury to determine readiness to return to sports? A systematic review. *BMC Sports Sci Med Rehabil.* 2021;13(1):142.
65. Cook G, Burton L, Hoogenboom B. Pre-participation screening: the use of fundamental movements as an assessment of function - part 1. *N Am J Sports Phys Ther.* 2006;1(2):62-72.
66. Taberner M, Haddad FS, Dunn A, Newall A, Parker L, Betancur E, et al. Managing the return to sport of the elite footballer following semimembranosus reconstruction. *BMJ Open Sport Exerc Med.* 2020;6(1):e000898.
67. Taberner M, van Dyk N, Allen T, Richter C, Howarth C, Scott S, et al. Physical preparation and return to sport of the football player with a tibia-fibula fracture: applying the 'control-chaos continuum'. *BMJ Open Sport Exerc Med.* 2019;5(1):e000639.
68. Morin JB, Le Mat Y, Osgnach C, Barnabò A, Pilati A, Samozino P, et al. Individual acceleration-speed profile in-situ: A proof of concept in professional football players. *J Biomech.* 2021;123:110524.
69. Theodoropoulos JS, Bettle J, Kosy JD. The use of GPS and inertial devices for player monitoring in team sports: A review of current and future applications. *Orthop Rev (Pavia).* 2020;12(1):7863.
70. Johnston RD, Gabbett TJ, Jenkins DG. Applied sport science of rugby league. *Sports Med.* 2014;44(8):1087-100.

71. Gabbett TJ. The training-injury prevention paradox: should athletes be training smarter and harder? *Br J Sports Med.* 2016;50(5):273-80.
72. Bourdon PC, Cardinale M, Murray A, Gatin P, Kellmann M, Varley MC, et al. Monitoring Athlete Training Loads: Consensus Statement. *Int J Sports Physiol Perform.* 2017;12(Suppl 2):S2161-s70.
73. Gabbett T, Sancho I, Dingenen B, Willy RW. When progressing training loads, what are the considerations for healthy and injured athletes? *Br J Sports Med.* 55. England2021. p. 947-8.
74. Alcalá EP, Garcia AM, Trench MG, Hernández IG, i Costa JRT, Seirul F, et al. Entrenamiento en deportes de equipo: El entrenamiento optimizador en el Fútbol Club Barcelona. *Apunts Educación física y deportes.* 2020;4(142):55-66.