Adapting the High Chaos phase of the 'control-chaos continuum': a bridge to team training

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Football | Rehabilitation | Return to Sport | Communication

Introduction

The return to sport (RTS) process after injury is complex, challenging the practitioner to implement and adapt a combination of processes which blend 'science' and 'art' to meet the specific demands of the player and their injury (1). On-pitch reconditioning is a critical aspect of a player's RTS journey, with the goal of preparing them for a return to the demands of team training/competition and onto a return to performance (RTPerf). We recently presented the 'control-chaos continnum' (CCC) as an adaptable framework to guide practitioners in the on-pitch reconditioning process utilising a constraints-led approach to shape the rehabilitation environment to the required goals (1,2). The CCC moves a player from high control to high chaos, progressively increasing running load while incorporating greater perceptual and reactive neurocognitive challenges, creating a sport-specific and ecological valid pathway (3,4,5,6).

High chaos is the last phase of the CCC and aims to return the player to the required training demands, emphasising position-specific conditioning and if warranted, drills that include worse-case scenario challenges (1). Depending upon the club environment, football coaches may also help to design drills that incorporate a greater tactical focus which provide greater neurocognitive stimulus and further facilitate the transition from rehabilitation to full team training.

Assessment of Risk

Depending on the severity of the injury, the length of absence from team training and the philosophy of team management, the use of partial and/or progressive team interaction can effectively form the most specific form of 'chaos' prior to a return to full team training/competition (Figure 1). In our experience, shared decision-making based on good internal communication and co-operation between coaching staff and performance/medical teams (7), and making appropriate risk assessments (8) with player input (9) are the cornerstones of successful rehabilitation. Collectively, the decision-making team may deem it suitable for the returning player to resume partial team training or progressive team interaction as the last step in the player's rehabilitation (Figure 2). However, they may conclude that re-injury risk exceeds risk tolerance and the player remains with the "rehabilitation practitioner" until it is agreed that adequate progression has been made (Figure 2). We use the term "rehabilitation practitioner" to denote an individual or individuals within the performance and/or medical teams with the educational background, skillset and experience to recondition elite players. This is a reconditioning process that goes beyond a return to 'function' (10,11), and requires specialist skills to prepare the player for the RTPerf that elite football demands, including knowledge of training and monitoring processes in healthy players.

From our personal experiences working in the English Premier League, different coaching teams may take different stances on RTS after injury, influenced by their own philosophy, experience and football culture. The coaching team's decision will also be determined by contextual factors such as the importance of the player to the team, the availability of alternative players, the opposition and the importance of matches at the time of the potential return/phase of season. Some coaches consider the partial or progressive approach an effective strategy to re-introduce the player to the group and an opportunity for them to gain insight on the player's condition. Others deem the player ready only when they can resume full unrestricted training, with players then following the CCC pathway through to high chaos with the rehabilitation practitioner (1). Adaptability is key, therefore if the conceptual goals of rehabilitation have been achieved by the end of the moderate chaos phase, the high chaos phase may be modified appropriately to accelerate the players interaction with team and provide progressive involvement in more perceptually challenging situations alongside technical and tactical input from the coaching staff.

Within the high chaos phase, whether with the rehabilitation practitioner, or in partial or progressive team interaction, it is also important that not all elements of the session are 'chaotic'. Session content is gradually progressed to achieve the required outcomes by moving from drills with a high level of control to the required level of chaos deemed suitable for the returning player. Environmental and/or task constraints in drills are progressively adjusted to alter the stability of the landscape, challenging the player to adapt to the imposed demands and produce the required output (12). The imposed constraints are manipulated to achieve the desired outcomes i.e. movement variability, associated running load demands and technical and perceputal challenges (13). While not all these elements are measurable, they should be interpreted and subjectively quantified based on the practitioners experience of the sport, of the player and understanding of the game. Player feedback on how they feel they need to be challenged may provide critical further detail and the final piece of the puzzle.

Adapting the Chaos

Both in short-term and long-term injuries, the high chaos phase may be modified by using shorter or longer periods within each subphase. An understanding of how to manipulate the interaction between players in the team training environment and the constraints placed upon them within drill content enables the rehabilitation practitioner to communicate appropriate adjustments to session content. In healthy players, coaching and performance teams manipulate pitch

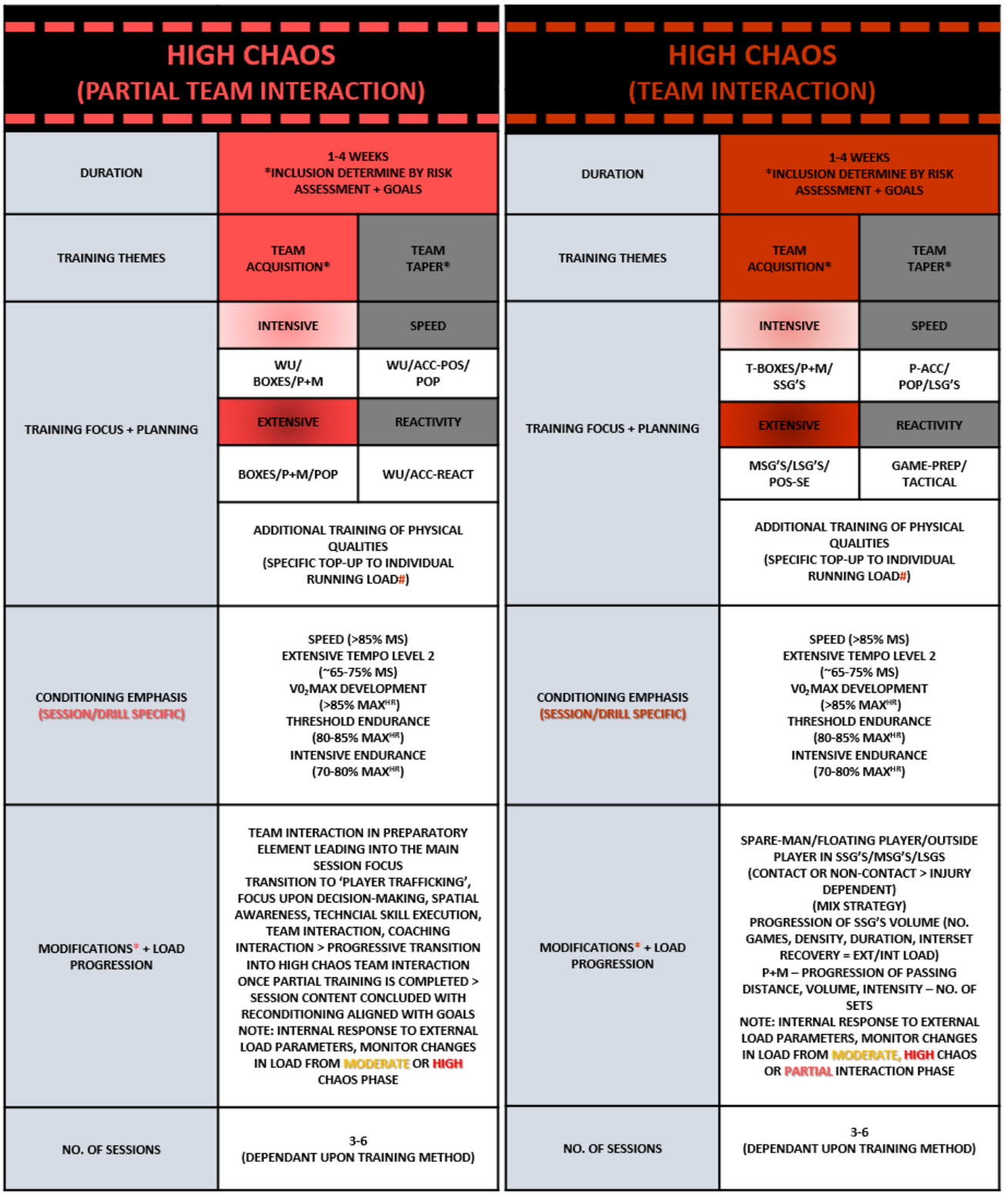

Fig. 1. Subphases of the High Chaos phase of the 'control-chaos continuum' – High Chaos: Partial Team Interaction and Team Interaction. Chaos = behaviour/actions/movement that is unpredictable as to appear random/reactive, i.e. chaotic situation. Sub-phases can be adjusted specific to injury diagnosis, estimated tissue healing times, and expected return to training. MS = maximal speed, MAX^{HR} = maximal heart-rate, WU = warm-up, ACC-POS = positional acceleration, ACC-REACT = reactive acceleration, POS-SE = positional speed-endurance, P+M = pass and move, WOA = waves of attack, POP = pattern of play, SSG's = small sides games, MSG's = medium sized games, LSG's = large sided games, T-Boxes = transition boxes, Ext = external, Int = internal, No. = number of, Game-Prep = match preparation, VO_2max = maximal oxygen uptake.

density (per m^2), intensity, duration, exercise: rest ratios and coaching instruction (rules/cues) to overload or reduce load on players in accordance with the training outcomes and phase of the season. These variables are therefore a valuable tool with which the rehabilitation practitioner can influence the imposed demands placed on the returning player in the team training environment. With this understanding, the rehabilitation practitioner can communicate the appropriate level of session involvement with the coaching team i.e. the suitability of drills/drill modifications in line with the conceptual goals and progress of the player through the RTS process. Strength and power diagnostics provide a status report on the players underlying neuromuscular qualities and on their response to loading, which alongside the player's training status (global positional system (GPS) running load, heart rate and subjective response data and the level of technical proficiency achieved (the technical actions completed), can inform the risk assessment process and shared decision-making on the level of team interaction required (1,14).

The global aims of the high chaos phase are to return the player to pre-injury weekly training demands and should include drills designed to test worst-case scenarios (high speed/high chaos) and partial or progressive team interaction does not alter these aims. Team interaction provides an opportunity to increase the perceptual and neurocognitive demands placed upon the player, especially where in practice, replicating the demands of sport in competition may be challenging in the absence of support staff or other players to create high chaos rehabilitation scenarios. There are also circumstances where training with the first team is not feasible and the returning player instead trains with the development squad. As adaptability is key in the challenging environment of elite sport and each injury presents a unique situation, the subphases of high chaos should be modified by the practitioner according to the specifics of the injury, the player and the club environment, to ensure the required conceptual goals are met (Figure 1).

High Chaos: Partial Team Interaction

Aims. Introduce the player to partial elements of team training and the club-specific training structure (with restrictions agreed in the risk assessment process), increase player confidence and motivation during the final stages of rehabilitation.

The level of partial team training can be determined by considering the specifics of the player and the type and severity

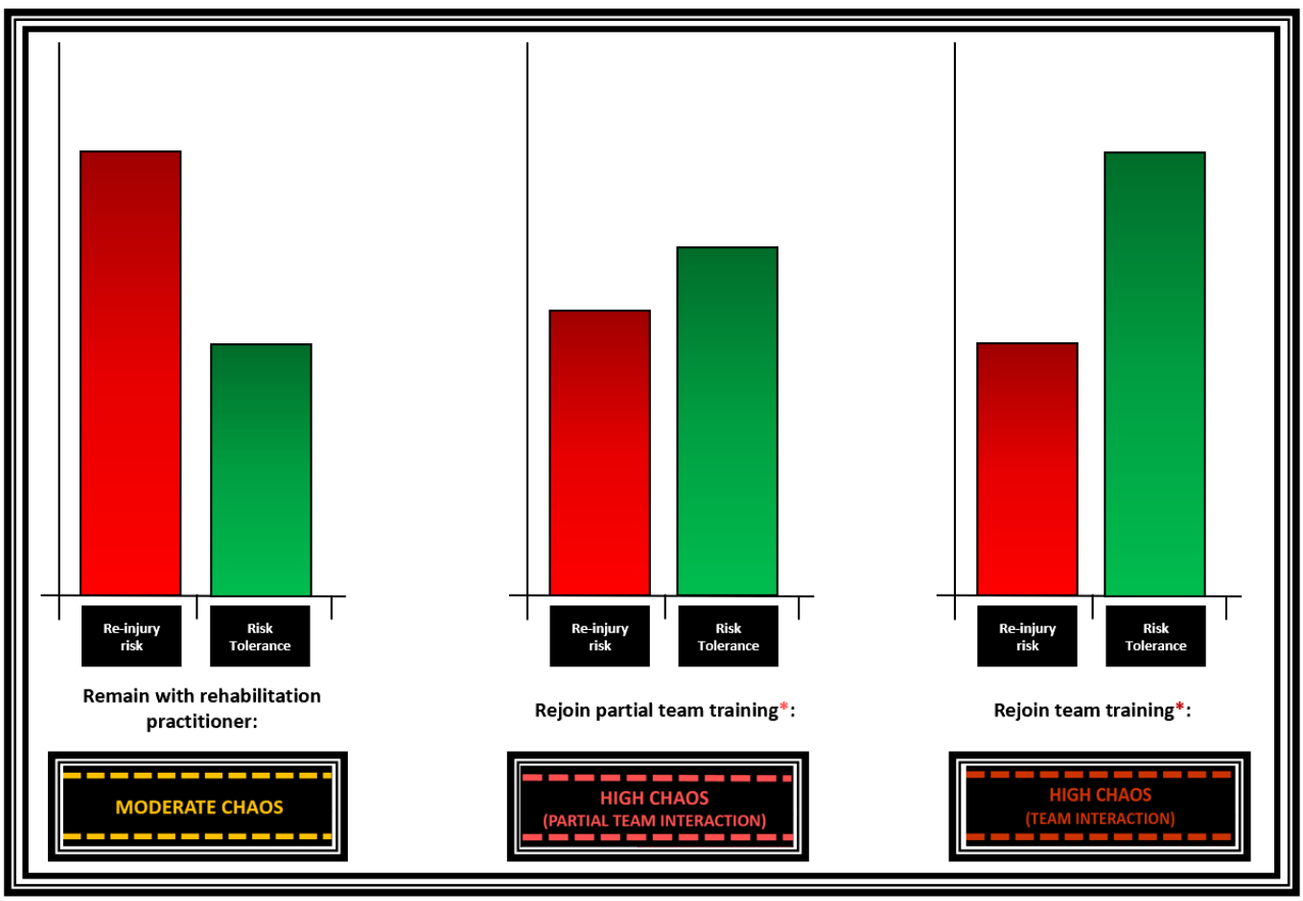

Fig. 2. Risk assessment process to determine the rehabilitation process for a player returning from injury. The risk assessment process follows the Strategic Risk and Risk Tolerance (StARRT) framework (8) but also includes the quantitative and qualitative aspects of load achieved during on-pitch rehabilitation in tier 3 of the decision-making model. (A) Evaluation of re-injury risk higher than risk tolerance = player remains with rehabilitation practitioner in the moderate chaos phase, (B) level of risk tolerance slightly higher than re-injury risk = the player joins partial team training and completes additional rehabilitation with the rehabilitation practitioner under the High Chaos phase of the 'control-chaos continuum', (C) level of risk tolerance substantially higher than re-injury risk = player completes high chaos under team interaction conditions. Note: contextual factors may also influence the phase a player re-joins partial or team interaction subphase. * = modifications to team interaction specific to injury.

of the injury, length of absence from training, positional characteristics and risk factors for re-injury i.e. quadriceps strain – ball striking etc alongside the team training content and in-season phase. Partial training means the player is involved in more controlled elements of team training and drills may be modified to address potential concerns of the shared decision-making team regarding the level of risk exposure. Risk: benefit is assessed, whereby concerns around risk exposure must be considered alongside the benefit of exposing the player to load under 'chaotic' conditions. This loading provides the stimulus for adaptations, increases the level of tolerance and ultimately mitigates re-injury risk. Therefore, partial team interaction should be progressed if re-injury risk associated with the elements of the team training the player is going to be involved in is estimated to be exceeded by their level of tolerance to those risks.

The degree of integration will depend upon the nature of the injury, the players level of confidence about involvement in team training (15), and upon the training methodology and game-model used by the coaching team. For example, on an intensive training day (acquisition block) the player may be included in the warm-up and interaction in "boxes", but remain on the periphery before participating in the "pass and move" drill (Figure 3). After having completed the agreed team content, the player would then rejoin the rehabilitation practitioner and additional support staff for positional acceleration/conditioning aspects in the high chaos phase of the CCC (Figure 3). Importantly, insights from a coaching perspective can be gleaned about the player during partial training exposure, including their level of 'sharpness' and their decision-making ability under high 'player traffic' conditions (16). Within this subphase, as the running load achieved is a combination of partial team training and high chaos phase training with the rehabilitation practitioner, we suggest real-time monitoring of GPS data to allow the practitioner to fine-tune session outcomes with the intention of not exceeding the current estimated load capacity of the player, potentially resulting in a setback to the rehabilitation plan.

High Chaos: Team Interaction

Aims. Involve player in modified team training, modification of drills/game-based training and training parameters in line with team training content/club-specific structure and in-season micro-cycle (restrictions agreed in the risk assessment).

High chaos: team interaction represents the most powerful form of high chaos to challenge the player before resuming full team training. As in the previous phase, within this subphase there is a high level of adaptability to the individual in terms of the level of integration within 'chaotic' elements of session content. Drills can be modified to alter player involvement, with type and level of modification influenced by the injury type, severity and length of absence from training alongside an awareness that excessive load increases potential for re-injury risk (17). Within this subphase, good communication between the coaching, performance and medical teams is even more critical as the player is now part of the club-specific training structure, but with potential modifications to the player's interaction within drills/games and conditioning. For example, on an extensive training day (acquisition block), modification to large sided-games where they are a "floating player" in 9v9 games (9v9+1) under non-contact conditions i.e. the player cannot be tackled (Figure 4). The timing of their return - during a pre-season, or during periods of fixture congestion - should also be taken into consideration in planning.

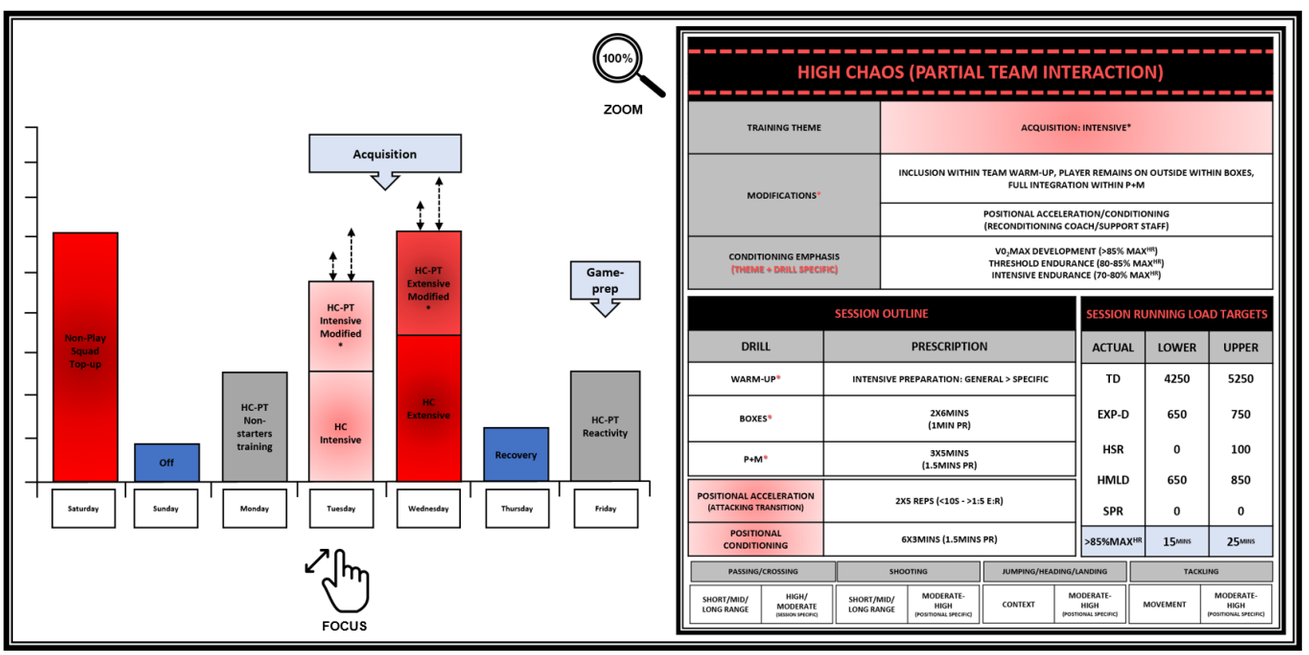

Fig. 3. Example High Control: partial team interaction micro-cycle and session planner. Focus = Tuesday (Intensive) > Zoom = Intensive session daily plan with partial team interaction and session content to be completed with the reconditioning coach under the high chaos phase of the 'control-chaos continuum'. HC = high chaos, HC-PT = high chaos: partial team interaction, MAX^{HR} = maximal heart-rate, * = session modifications, P+M = pass and move, PR = passive recovery, TD = total distance, EXP-D = explosive distance (distance accelerating/decelerating i.e. from 2 to 4 m·s^{-1} <1 s), HSR = high-speed running (>5.5 m·s^{-1}), HMLD = high metabolic load distance (distance covered above 25.5 W/kg; sum of HSR and EXP-D), SPR = sprint distance (>7 m·s^{-1}), VO_2max = maximal oxygen uptake.

Drill modifications such as involvement as a "floating player" or an "outside man" allow the returning player to be involved in game-based activities, modified to reduce the number of pressured moments, excessive running load and imposed physiological strain placed upon them (18,19). This allows the coach to ease the player back into the 'chaotic' elements of team training and importantly, allows the player to self-limit tempo within game-based activities. Despite the potential reduction in musculoskeletal, neuromuscular and cardiovascular load, it is important to be aware that the level of movement variability will always be higher in team training – this is the 'chaos' we are aiming to expose the player to, and by definition cannot be completely controlled. By carefully quantifying, including in real time, both potential under- as well as over- load can be identified by the performance team, and adjustments can be made where appropriate, including supplementing team interaction if required.

Alongside drill modifications, communication between the coaching team and the rehabilitation practitioner enables appropriate adjustments to training parameters to be made. This includes cardiovascular loading strategies and exercise: rest ratios, aligning the returning player with the training focus of the team to ensure the required stimulus is achieved alongside considerations of the coaches' game-model (20). Chronic running load, internal responses and player feedback should be continually monitored. Modifications to session content appropriate to the specific requirements of the case and the player's load-response data may be made while aligning with the conceptual goal of addressing factors that contribute to the development of risk tolerance prior to the RTS decision-making process (21). It is vital that the player's perspective also informs the RTS decision-making process. At an elite level, players are highly attuned to their body and are highly motivated both to not reinjure upon RTS, and to immediately perform at a high level (9,22). However as the player draws closer to return, the coach's decision-making is increasingly influenced by the aforementioned contextual factors. This may result in a return to competition which the performance/medical team might consider premature, and it is therefore critically important that the performance/medical team ensure there has been adequate prior exposure to 'chaotic' conditions to raise the level of risk tolerance.

Conclusion

The RTS process following injury is complex, particularly in an elite environment where risk: reward management is key – balancing team success and individual players health and performance is the ultimate goal. Adaptability is critical, and particularly so in the phase of rehabilitation that bridges the transition to team training. Depending upon the coaching staff's philosophy on RTS and appropriate communication between medical and performance staff, the sub-phases of high chaos provide the highest level of Chaos, representing critical preparation for the demands of a return to full team training. This process, a blend of the 'science' and 'art', requires flexibility and the ability of the rehabilitation practitioner to adapt processes to meet the demands of an ever-changing environment.

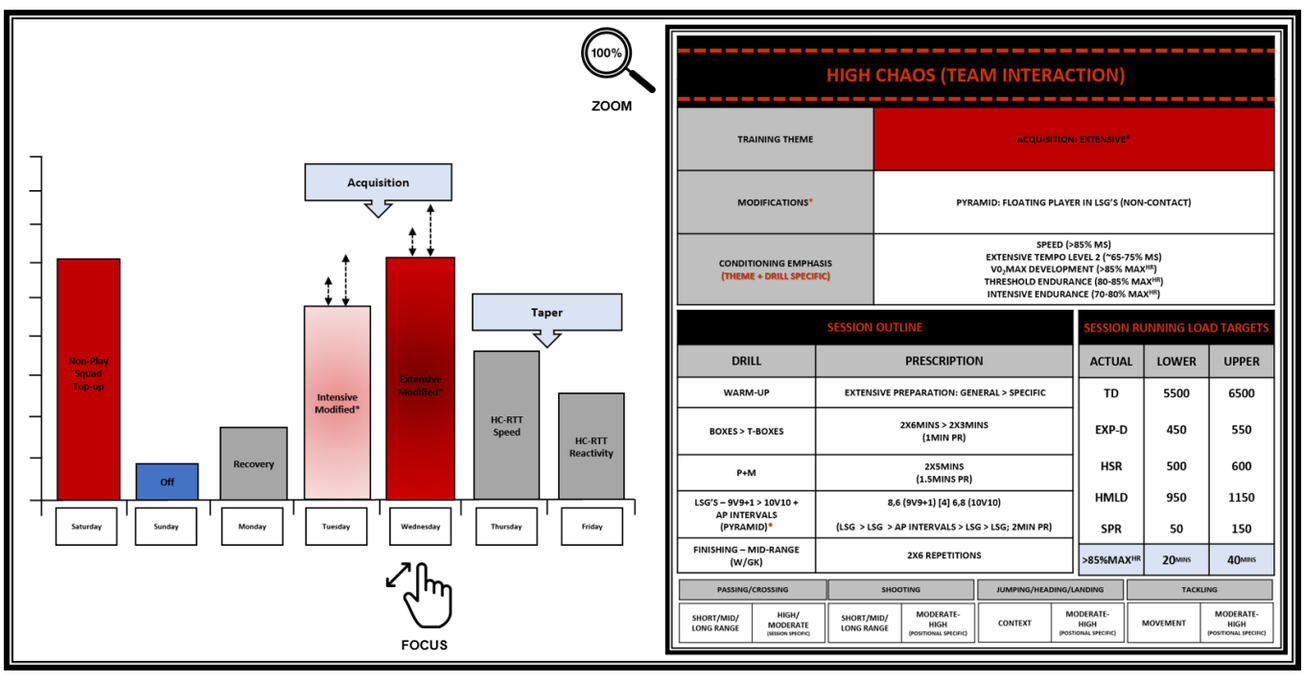

Fig. 4. Example High Control: team interaction micro-cycle and session planner. Focus = Wednesday (Extensive*) > Zoom = Extensive session daily plan modifications to the session content. HC = high chaos, Modified* = session/drill or training modifications, HC-RTT = High Chaos Return to Training (modified where applicable) MAX^{HR} = maximal heart-rate, * = session modifications, P+M = pass and move, PR = passive recovery, TD = total distance, EXP-D = explosive distance (distance accelerating/decelerating i.e. from 2 to 4 $m{\cdot}s^{-1}$ <1 s), HSR = high-speed running (>5.5 $m{\cdot}s^{-1}$), HMLD = high metabolic load distance (distance covered above 25.5 W/kg; sum of HSR and EXP-D) , SPR = sprint distance (>7 $m{\cdot}s^{-1}$), GK = goalkeeper, LSG's = large sided games, t-boxes = transition boxes, v = versus, AP = aerobic power, VO_2max = maximal oxygen uptake.

Practical Applications

- RTS processes should be adaptable, blending 'science' and the 'art' to meet the specific needs of the individual and the injury. 'One-size' fits all protocols may not address the substantial variability that exists between injuries, player characteristics and their physical and cognitive response to load.
- The 'control-chaos continuum' can be adapted to the requirements of the coaching staff philosophies and approaches to RTS after injury, understanding that with appropriate risk: benefit assessment, partial and/or progressive team interaction can be the most effective and specific form of 'chaos' prior to full team training/competition.
- Prior to implementing the subphase of high chaos within their RTS processes, it is vital for practitioners have a detailed understanding of not only the physical but also the neurocognitive demands of team training alongside the coaches' game-model in order to carefully and progressively integrate the returning player back into the team training.

Conflict of Interest

There are no conflicts of interest.

References

1. Taberner M, Allen T, Cohen DD. Progressing rehabilitation after injury: consider the 'control-chaos continuum' Br J Sports Med. 2019;53:1132-1136.
2. Newell KM. Constraints on the development of coordination. In: Wade MG, Whiting H, eds. Motor development in children. Aspects of coordination and control. Dordrecht, The Netherlands: Martinus Nijhoff 1986:341-360.
3. Grooms DR, Myer GD. Upgraded hardware - What about the software? Brain updates for return to play following ACL reconstruction. Br J Sports Med 2017;51:418–9.
4. Taberner M, Cohen DD. Consider the chaos: creating ecological validity in the Return to Sport process. Br J Sports Med Guest Blog. Available online: http://https://blogs.bmj.com/bjsm/
5. Davids K. Ecological Validity in Understanding Sport Performance: Some Problems of Definition. Quest. 1988;40(2):126-136
6. Schmuckler, M. What is ecological validity? A dimensional analysis. Infancy. 2001;2(4):419-436.
7. Ekstrand J, Lundqvist D, Davison M, et al. 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;53:304-308.
8. Shrier I. Strategic Assessment of Risk and Risk Tolerance (StARRT) framework for return-to-play decision-making. Br J Sports Med. 2015;49:1311-1315.
9. King J, Roberts C, Hard S, et al. Want to improve return to sport outcomes following injury? Empower, engage, provide feedback and be transparent: 4 habits! Br J Sports Med. 2019;53:526-527.
10. Kraemer W, Denegar C, Flanagan S. Recovery from injury in sport: considerations in the transition from medical care to performance care. Sports Health. 2009;1(5):392-395.
11. Walsh JM, Swangard DM, Davis T, McPhee SJ. Exercise counselling by primary care physicians in the era of managed care. Am J Prev Med. 1999;16(4):307-313
12. Davids K, Arau´jo D, Shuttleworth R. Applications of dynamical systems theory to football. In: Reilly T, Cabri J, Arau´jo D, editors. Science and football V. London: Routledge, 2005; 547-60
13. Handford C, Davids K, Bennett S, et al. Skill acquisition in sport: some applications of an evolving practice ecology. J Sports Sci. 1997;15:621–40.
14. Taberner M, Cohen DD. Physical preparation of the football player with an intramuscular hamstring tendon tear: clinical perspective with video demonstrations. Br J Sports Med. 2018;52:1275-1278.
15. Gómez-Piqueras P, Ardern C, Prieto-Ayuso A, et al. Psychometric Analysis and Effectiveness of the Psychological Readiness of Injured Athlete to Return to Sport (PRIA-RS) Questionnaire on Injured Soccer Players. Int J Environ Res Public Health. 2020;17:1536-1550.
16. Taberner M, Allen, T, Constantine E, Cohen DD. From Control to Chaos to Competition: Building a Pathway to Return to Performance following ACL Reconstruction. Aspetar Sports Medicine Journal. 2020;9:84-94
17. Gabbett TJ. The training—injury prevention paradox: should athletes be training smarter and harder? Br J Sports Med. 2016;50:273-280.
18. Lacome M, Simpson BM, Cholley Y, Buchheit M. Locomotor and heart rate responses of floaters during small-sided games in elite soccer players: effect of pitch size and inclusion of goal keepers. Int J Sport Physiol. 2018, 13, 668–671.
19. Rábano-Muñoz A, Asian-Clemente J, Sáez de Villarreal E, et al. Age-Related Differences in the Physical and Physiological Demands during Small-Sided Games with Floaters. Sports 2019, 7, 79-88.
20. Delgado-Bordonau JL, Mendez-Villanueva A. The Tactical Periodisation Model. In: Sum ME, ed. Fitness in Soccer: The Science and Practical Application, 2014.
21. Dijkstra HP, Pollock N, Chakraverty R, et al. Return to play in elite sport: a shared decision-making process. Br J Sports Med. 2017;51:419–20.
22. Defoe J. Trusting the experience of the experienced athlete. Br J Sports Med. 2018;52:1554-1555.

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