International Journal of Sport Studies for Health

Journal Homepage

Motor Learning in the Ecological-Dynamic Approach: A Systematic Review

Tiziana. D'Isanto[1], Giuseppe. Giardullo[1], Pompilio. Cusano[1*], Manuele. Taleb[2], Luca. Molinaro[3], Giuseppe. Di Lascio[4]

1. Research Center of Physical Education and Exercise, University of Pegaso, Italy
2. Research Center of Physical Education and Exercise, Digital Pegaso University, Naples, Italy
3. Department of Applied Science and Technology, ECampus University, Italy
4. Department of Neuroscience, Biomedicine and Movement, University of Verona, Italy

*** Corresponding author email address:** pompilio.cusano@unipegaso.it

A r t i c l e I n f o

Article type:
Review Article

How to cite this article:
D'Isanto, T., Giardullo, G., Cusano, P., Taleb, M., Molinaro, L., & Di Lascio, G. (2026). Motor Learning in the Ecological-Dynamic Approach: A Systematic Review. *International Journal of Sport Studies for Health*, *9*(4), 1-7.
http://dx.doi.org/10.61838/kman.intjssh.5212

A B S T R A C T

Objective: This systematic review aimed to synthesize recent evidence on the ecological dynamics approach in motor learning, with particular attention to its application in sport and educational contexts.

Methods and Materials: The review was conducted in accordance with PRISMA 2020 guidelines. Scopus and Google Scholar databases were searched for studies published between 2015 and 2024. A total of 4,387 records were identified, and 11 studies were included in the final synthesis. The included literature comprised heterogeneous study designs, including empirical studies and conceptual contributions, addressing technical skill acquisition, adaptability, creativity, perceptual-cognitive development, and pedagogical applications.

Findings: Overall, the findings suggest that ecological dynamics-informed approaches may support adaptive motor learning and functional variability, although conclusions should be interpreted cautiously due to variability in study design and methodological quality.

Conclusion: The results highlight the practical relevance of constraint-based approaches for coaches and physical education teachers, while emphasizing the need for more rigorous and comparable empirical research.

Keywords: *Ecological Dynamics Approach; Motor Learning; Motor Task; Skills; Transfer*

Article history:
Received 10 April 2026
Revised 03 May 2026
Accepted 12 September 2026
Initial Publication 20 September 2026
Final Publication 01 October 2026

1. Introduction

Motor learning is a complex and dynamic process through which individuals acquire, stabilize, and continuously adapt functional motor patterns to effectively interact with their surrounding environment (1, 2). Rather than being a linear or static phenomenon, motor learning is characterized by ongoing adaptation to changing internal and external conditions. Traditional cognitivist theories (3) conceptualize movement primarily as the result of internal representations, motor programs, and executive planning processes. Within this framework, learning is often understood as the progressive refinement of pre-defined movement patterns through repetition and feedback. In contrast, the ecological dynamics approach conceptualizes motor behavior as an emergent property of the continuous interaction between the individual, the task, and the environment (4-6). Rooted in ecological psychology and dynamic systems theory, this perspective emphasizes the inseparability of perception and action, the functional role of movement variability, and self-organization processes as fundamental mechanisms underpinning motor learning (7-10). From this viewpoint, variability is not interpreted as noise or error, but rather as a functional resource that allows learners to explore multiple movement solutions and adapt effectively to contextual constraints. Over recent decades, physical activity and sport have been increasingly recognized as powerful tools for fostering not only motor development (11), but also cognitive, emotional, and socio-relational skills across the lifespan, from childhood to adulthood (12-15). Within this broader educational and developmental framework, the ecological dynamics approach has gained growing relevance, as it places the learner at the center of an active process of adaptation and meaning-making through movement (5). In particular, it highlights variability and exploration as essential conditions for the emergence of flexible, adaptive, and context-sensitive motor behaviors (16). This theoretical shift has stimulated increasing interest in alternative models of motor teaching and learning, moving away from prescriptive, technique-centered instruction toward learner-centered and constraints-led approaches (17, 18). According to the ecological dynamics approach, motor learning emerges from the dynamic interplay among organismic, environmental, and task constraints, without the need for centralized control or pre-programmed solutions (19, 20). Learners are viewed as active agents who perceive affordances offered by the environment relative to their own capabilities and who self-organize adaptive movement solutions in real and variable contexts (21-23). This perspective stands in clear contrast to traditional instructional models that prioritize technical repetition, error correction, and the standardization of movement execution (24). Within the ecological-dynamic framework, motor variability is instead considered a key driver of learning, facilitating the search for heuristic and functional solutions (25) and enabling the stabilization of effective coordination patterns through the systematic manipulation of individual (e.g., anthropometric characteristics), environmental (26), and task-related constraints (27). Despite a growing body of literature demonstrating the effectiveness of the ecological-dynamic approach in enhancing motor competence, adaptability, and performance in variable and unpredictable environments, relatively limited attention has been devoted to its potential effects on the transfer of cognitive, perceptual, and decision-making skills beyond purely motor contexts (28). This gap restricts the full exploitation of the educational and training potential of the ecological-dynamic paradigm, particularly in school and sport settings where the ultimate goal extends beyond technical proficiency to encompass holistic individual development. Considering these considerations, the present review aims to analyze and synthesize recent scientific evidence on the effectiveness of the ecological-dynamic approach in promoting adaptive and transferable motor learning, with particular emphasis on its practical implications for educational and sporting contexts.

2. Methods and Materials

2.1 Study design

This study was conducted as a systematic review and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines.

2.2 Search strategy

A systematic literature search was conducted in Scopus and Google Scholar to identify relevant studies published between January 2015 and December 2024. The final search was performed in March 2025. The search strategy included combinations of the following keywords: “ecological dynamics”, “ecological dynamics approach”, “constraints-led approach”, “motor learning”, “skill acquisition”, “motor task”, “transfer”, “adaptation”, “physical education”, and “sport”, using Boolean operators (AND/OR). A

representative search string used in Scopus was: ("ecological dynamics" OR "ecological dynamics approach" OR "constraints-led approach") AND ("motor learning" OR "skill acquisition" OR "motor task") AND ("transfer" OR "adaptation" OR "physical education" OR "sport"). Google Scholar was used as a complementary search source to broaden retrieval. Records identified through Google Scholar were screened using the same eligibility criteria applied to the database search.

2.3 Eligibility criteria

Studies were included in the review if they met specific criteria. In particular, only articles published in English between 2015 and 2024 were considered. Furthermore, studies were required to address ecological dynamics or constraints-led approaches in relation to motor learning and to be situated within sport, physical education, or movement-related educational contexts. Only original full-text articles were included in order to ensure the relevance and completeness of the data analyzed. Studies were excluded if they did not meet these criteria. More specifically, reviews, books, book chapters, editorials, and conference abstracts were not considered. In addition, studies that were not directly related to motor learning or ecological dynamics were excluded. Articles that were not available in full text or not written in English were also removed from the final selection.

2.4 Study selection, data extraction, and quality appraisal

After the initial search, records were screened for relevance. Titles and abstracts were first examined, and potentially eligible studies were then assessed in full text according to the predefined inclusion and exclusion criteria. The selection process followed the PRISMA phases of identification, screening, eligibility, and inclusion. For each included study, the following information was extracted: authors, year of publication, study design, context, main focus, and principal findings. Given the heterogeneity of the included literature, particularly the presence of both empirical and conceptual contributions, methodological quality was considered qualitatively in the interpretation of findings. Particular attention was paid to study design, sample characteristics, intervention scope, and clarity of reported outcomes in the empirical studies.

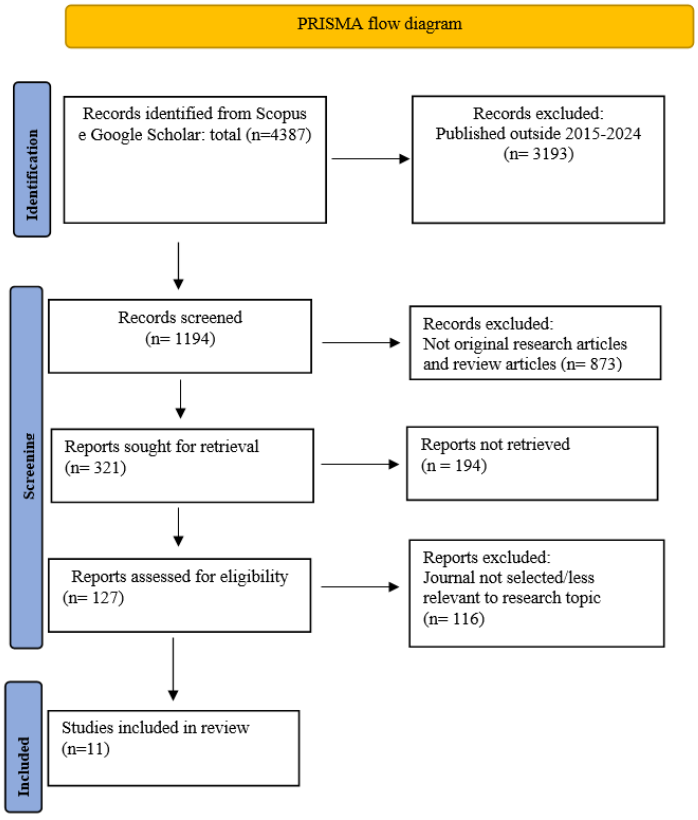

Figure 1. PRISMA flow diagram of the study selection process

3. Results

After conducting the initial search, a total of 4,387 records were identified. These records were screened through several stages, leading to the inclusion of 11 studies in the final synthesis (Figure 1). The included studies were heterogeneous and comprised both empirical and conceptual contributions.

The PRISMA flow diagram illustrates the phases of identification, screening, eligibility assessment, and final inclusion of studies. Of the 321 reports sought for retrieval, 194 could not be retrieved because the full text was not accessible through the institutional subscriptions and open-access sources available to the review team (e.g., paywalled articles or conference records without an archived full text). No formal deduplication step was performed across the two databases; the overlap between Scopus and Google Scholar records was not systematically quantified, and this is acknowledged as a methodological limitation of the search strategy.

Table 1. Summarizes the characteristics of the included studies.

Authors (Year)	Study type	Context	Main focus
Esposito et al., 2024	Experimental	Soccer	Skill performance
Pol et al., 2020	Conceptual	Sport	Complex systems
Moreau et al., 2015	Experimental	Cognitive-motor training	Cognitive effects
Práxedes et al., 2022	Observational/empirical	Soccer	Decision-making and task constraints
Chow et al., 2021	Pedagogical	Physical education	Nonlinear pedagogy
Wood et al., 2023	Conceptual	Coaching	Coach as learning designer
Caldeira et al., 2024	Experimental	Volleyball	Skill adaptation
Marshall et al., 2024	Conceptual	Rugby	Creativity
Adè et al., 2022	Conceptual	Physical education	Enactive and ecological integration
Rudd et al., 2021	Conceptual	Physical education	Ecological physical education
Woods et al., 2020a	Conceptual	Sport coaching	Learning design

4. Discussion

Overall, the reviewed literature suggests that ecological dynamics-informed approaches may offer meaningful advantages for motor learning, particularly in relation to adaptability, functional variability, and responsiveness to changing contexts. However, these findings should be interpreted cautiously because of the heterogeneity of study designs, participant characteristics, and outcome measures across the included studies. The ecological-dynamic paradigm has progressively gained prominence within scientific research, applied sport settings, and educational contexts, establishing itself as a robust and theoretically grounded alternative to traditional instruction models based on repetition, standardization, and error correction. Emerging empirical evidence, particularly from the experimental study conducted by Esposito et al. (2024) (29), supports the effectiveness of the ecological dynamics approach in the training of young soccer players. Their findings reveal significantly greater improvements in passing performance among participants exposed to constraint-led training environments compared to peers trained through prescriptive methodologies. These results align with a broader theoretical framework that reconceptualizes learning as an emergent, situated, and context-dependent process, rather than as a linear transmission of technical knowledge from coach to athlete. Beyond the motor domain, several studies suggest that ecological dynamics based training may positively influence perceptual-cognitive and executive functions. In this regard, the work of Moreau et al. (2015) demonstrates that complex motor programs designed according to ecological principles can enhance executive functioning and cognitive flexibility, indicating that the benefits of this approach extend beyond motor skill acquisition alone. Extending this perspective, Pol et al. (2020) argue that the synergistic manipulation of constraints across individual, task, and environmental levels fosters a dynamic process of coach–athlete co-adaptation. This process, in turn, supports the transferability of problem-solving strategies to contexts that are not strictly motor-related, thereby reinforcing the educational value of ecological dynamics approach training frameworks. Empirical investigations conducted in sport-specific contexts further substantiate these claims. Práxedes et al. (2022) demonstrate that the modulation of defensive opposition during attacking tasks in soccer significantly shapes the technical-tactical solutions adopted by players (30). Similarly, Caldeira et al. (2024) show that the deliberate introduction of functional variability within

attacking drills in volleyball promotes the emergence of more effective and adaptable motor patterns compared to standardized training approaches (31). These findings reinforce the notion that learning environments rich in variability and affordances facilitate the exploration of diverse and context-sensitive movement solutions. Creativity, a dimension often marginalized within prescriptive training models, emerges as a central construct within the ecological dynamics approach. As argued by Marshall et al. (2024), constraint-led and non-linear learning environments not only support the development of functional behaviors but also create optimal conditions for the emergence of creative actions in sport (32). Within this framework, athletes are no longer viewed as passive executors of predefined tasks, but as active agents who explore, adapt, and co-construct novel motor solutions in response to evolving situational demands. The pedagogical implications of the ecological dynamics approach

have also been extensively explored within educational settings. Chow et al. (2021) illustrate how non-linear pedagogy can inform the design of more effective physical education lessons by promoting exploration, functional variability, and adaptive learning processes (16). In parallel, Rudd et al. (2021) and Adè et al. (2022) propose integrative models that combine ecological-dynamic and enactive perspectives, giving rise to innovative, embodied, and multidimensional teaching practices (33, 34). In particular, Adè et al. (2022) emphasize the complementarity between the enactive approach, which foregrounds lived bodily experience (33), and the ecological-dynamic framework, which enriches learning through the structured manipulation of affordances and constraints in physical education contexts. Another significant line of inquiry concerns the evolving role of the coach and teacher within ecological-dynamic learning environments. Woods et al. (2020a) and Wood et al. (2023) describe a paradigmatic shift in which training is no longer conceived as a process of correcting deviations from an idealized technical model (35, 36). Instead, coaching is reframed as the intentional design of learning environments that enable meaningful interactions between individuals and their contexts. Within this perspective, the coach assumes the role of a "designer of learning ecosystems," guiding learners' attention toward relevant affordances, facilitating exploration, and fostering creativity, particularly in complex and dynamic team sports. Despite the overall consistency and strength of the evidence, several methodological limitations emerge across the reviewed studies. Considerable heterogeneity is observed in terms of experimental designs, sample sizes and characteristics (e.g., youth versus adult populations, individual versus team sports), intervention durations, and outcome measures. This variability limits the feasibility of quantitative synthesis through meta-analytic procedures and complicates direct comparisons across studies. Finally, inter-domain transfer, i.e., the generalization of the benefits of the ecological dynamics approach to cognitive, emotional, or social contexts, remains an under-explored area. Longitudinal studies integrating cognitive, socio-affective, and motor indicators are therefore needed to assess the sustainability and scope of the improvements induced by this approach.

5. Conclusion

The available evidence suggests that the ecological dynamics approach represents a promising framework for promoting adaptive motor learning and enhancing the interaction between individuals and their environment. It appears particularly relevant for sport and educational settings in which flexibility, exploration, and context-sensitive performance are central. However, the current body of literature remains heterogeneous in terms of methodological design, sample characteristics, and reported outcomes. For this reason, conclusions regarding the superiority of ecological dynamics over traditional prescriptive approaches should be considered preliminary. Future research should adopt more robust empirical designs, clearer intervention reporting, and more comparable outcome measures in order to strengthen the evidence base and support more rigorous synthesis.

Authors' Contributions

The authors contributed equally to the design, implementation, and writing of the research sections.

Declaration

During the preparation of this manuscript, ChatGPT (OpenAI) was used solely for English-language editing, grammar correction, and improvement of readability. It was not used for study design, data generation or collection, statistical analysis, or scientific interpretation of the findings. All AI-assisted text was critically reviewed and approved by the authors. The authors take full responsibility for the accuracy, originality, and integrity of the manuscript.

Declaration of Interest

The authors report no conflict of interest.

Funding

The authors declare no financial support for this research.

Ethical Considerations

Ethical approval was not required because this study was based exclusively on previously published data and did not involve human participants or identifiable personal information..

References

1. Esposito G, Ceruso R, Raiola G. The Impact Of Gentle Physical Activity On Psychophysical Well-Being In Older Adults: A Longitudinal Study. Retos: Nuevas Tendencias en Educación Física, Deporte y Recreación. 2025;67:509-21. [DOI]
2. Raiola G. Motor Learning And Teaching Method. Journal of Physical Education and Sport. 2017;17(S5):2239-43. [DOI]
3. Tomporowski PD, Mccullick B, Pendleton DM, Pesce C. Exercise And Children'S Cognition: The Role Of Exercise Characteristics And A Place For Metacognition. Journal of Sport and Health Science. 2015;4(1):47-55. [DOI]
4. Clark ME, Mcewan K, Christie CJ. The Effectiveness Of Constraints-Led Training On Skill Development In Interceptive Sports: A Systematic Review. International Journal of Sports Science & Coaching. 2019;14(2):229-40. [DOI]
5. D'Isanto T, Aliberti S, Raiola G, D'Elia F. Assessment Of Motor Skills In 5–6 Year Old Italian Children Using The Mabc-2: A Preliminary Study. Physical Activity Review. 2024;12(1):112-20. [DOI]
6. Woods CT, Mckeown I, Rothwell M, Araújo D, Robertson S, Davids K. Sport Practitioners As Sport Ecology Designers: How Ecological Dynamics Has Progressively Changed Perceptions Of Skill "Acquisition" In The Sporting Habitat. Frontiers in Psychology. 2020;11:654. [PMID: 32390904] [PMCID: PMC7194200] [DOI]
7. Ceruso R, Esposito G, D'Elia F. Analysis And Evaluation Of The Qualitative Aspects Of The Young Players. Journal of Physical Education and Sport. 2019;19(S5):1814-9. [DOI]
8. Kelso JS. Dynamic Patterns: The Self-Organization Of Brain And Behavior. Journal of Cognitive Neuroscience. 1996;8(4):385-6. [PMID: 23971510] [DOI]
9. Raiola G. Motor Control And Learning Skills According To Cognitive And Ecological Dynamic Approach In A Vision On Behaviorism, Cognitive, Gestalt And Phenomenology Theories. Mediterranean Journal of Social Sciences. 2014;5(15):504-6. [DOI]
10. Raiola G. Basketball Feint And Non-Verbal Communication: Empirical Framework. Journal of Human Sport and Exercise. 2015;10(1):S360-S8. [DOI]
11. Invernizzi PL, Signorini G, Rigon M, Larion A, Raiola G, D'Elia F, et al. Promoting Children'S Psychomotor Development With Multi-Teaching Didactics. International Journal of Environmental Research and Public Health. 2022;19(17):10939. [PMID: 36078655] [PMCID: PMC9517746] [DOI]
12. Aliberti S, D'Isanto T, D'Elia F. Evaluating The Impact Of A Laboratory-Based Program On Children'S Coordination Skills Using The Mabc-2. Education Sciences. 2025;15(5):527. [DOI]
13. Bailey R, Armour K, Kirk D, Jess M, Pickup I, Sandford R, et al. The Educational Benefits Claimed For Physical Education And School Sport: An Academic Review. Research Papers in Education. 2009;24(1):1-27. [DOI]
14. D'Isanto T, Aliberti S, Altavilla G, Esposito G, D'Elia F. Heuristic Learning As A Method For Improving Students' Teamwork Skills In Physical Education. International Journal of Environmental Research and Public Health. 2022;19(19):12596. [PMID: 36231894] [PMCID: PMC9566243] [DOI]
15. Raiola G, D'Isanto T, Aliberti S, Merati G, D'Elia F. Active Breaks To Promote Sustainable Cognitive Development In Primary School Children. Sustainability. 2025;17:6616. [DOI]
16. Chow JY, Komar J, Davids K, Tan CWK. Nonlinear Pedagogy And Its Implications For Practice In The Singapore Pe Context. Physical Education and Sport Pedagogy. 2021;26(3):230-41. [DOI]
17. Altavilla G, Esposito G, Ceruso R, Di Domenico F, D'Isanto T. Profile And Differences In Anthropometric Data And Jumping Ability Performance Between Elite And Amateur U16 Volleyball Players. Physical Education: Theory and Methodology. 2022;22(2):237-41. [DOI]
18. D'Isanto T, Altavilla G, Esposito G, D'Elia F, Raiola G. Heuristic Learning And Sport: Theoretical Lines And Operational Proposals. Encyclopaideia. 2022;26(64):69-80. [DOI]
19. Davids K, Button C, Bennett S. Dynamics Of Skill Acquisition: A Constraints-Led Approach: Human kinetics; 2008.
20. Seifert L, Button C, Davids K. Key Properties Of Expert Movement Systems In Sport: An Ecological Dynamics Perspective. Sports Medicine. 2013;43(3):167-78. [PMID: 23329604] [DOI]
21. Chow JY, Davids K, Button C, Renshaw I. Nonlinear Pedagogy In Skill Acquisition: An Introduction. 2nd ed: Routledge; 2022. [DOI]
22. D'Isanto T, Di Domenico F, Aliberti S, D'Elia F, Raiola G. Criticisms And Perspectives Of Heuristic Learning In Physical Education. Pedagogy of Physical Culture and Sports. 2022;26(2):93-100. [DOI]
23. Sannicandro I, Colella D. From The Ecological-Dynamic Approach To Learning Flexibility In The Motor And Sports Training Of The Young Athlete. Formazione & Insegnamento. 2023;21(2):146-52. [DOI]
24. Passos P, Davids K. Learning Design To Facilitate Interactive Behaviours In Team Sports. Revista Internacional de Ciencias del Deporte. 2015;11(39):18-32. [DOI]
25. Newell KM, Slifkin AB. The Nature Of Movement Variability. In: Piek JP, editor. Motor behavior and human skill: A multidisciplinary perspective: Human Kinetics; 1998. p. 143-60.
26. Renshaw I, Chow JY. A Constraint-Led Approach To Sport And Physical Education Pedagogy. Physical Education and Sport Pedagogy. 2019;24(2):103-16. [DOI]
27. Renshaw I, Davids K, Shuttleworth R, Chow JY. Insights From Ecological Psychology And Dynamical Systems: Theory Can Underpin A Philosophy Of Coaching. International Journal of Sport Psychology. 2009;40(4):580-602.
28. Button C, Seifert L, Chow JY, Araújo D, Davids K. Dynamics Of Skill Acquisition: An Ecological Dynamics Approach. 2nd ed: Human Kinetics; 2020. [DOI]
29. Esposito G, Ceruso R, Aliberti S, Raiola G. Ecological-Dynamic Approach Vs. Traditional Prescriptive Approach In Improving Technical Skills Of Young Soccer Players. Journal of

Functional Morphology and Kinesiology. 2024;9(3):162. [PMID: 39311270] [PMCID: PMC11417948] [DOI]
30. Práxedes A, Pizarro D, Travassos B, Domínguez M, Moreno A. Level Of Opposition Constrains Offensive Performance In Consecutive Game Situations: An Analysis According To Game Principles. Physical Education and Sport Pedagogy. 2022;27(3):291-303. [DOI]
31. Caldeira P, Paulo A, Veloso A, Infante J, Davids K, Araújo D. How Functional Movement Variability Facilitates Successful Skill Adaptation During The Volleyball Attack. International Journal of Sports Science & Coaching. 2024;19(2):668-76. [DOI]
32. Marshall C, Renshaw I, Russell S, Moy B, Gorman AD. Using A Constraints-Led Approach To Provide The Conditions To Cultivate Creativity In Rugby Union. Sport, Education and Society. 2024. [DOI]
33. Adé D, Seifert L, Mcgann M, Davids K. Enactive And Ecological Dynamics Approaches: Complementarity And Differences For Interventions In Physical Education Lessons. Physical Education and Sport Pedagogy. 2022;27(2):130-43. [DOI]
34. Rudd JR, Woods C, Correia V, Seifert L, Davids K. An Ecological Dynamics Conceptualisation Of Physical 'Education': Where We Have Been And Where We Could Go Next. Physical Education and Sport Pedagogy. 2021;26(3):293-306. [DOI]
35. Wood MA, Mellalieu SD, Araújo D, Woods CT, Davids K. Learning To Coach: An Ecological Dynamics Perspective. International Journal of Sports Science & Coaching. 2023;18(2):609-20. [DOI]
36. Woods CT, Mckeown I, O'Sullivan M, Robertson S, Davids K. Theory To Practice: Performance Preparation Models In Contemporary High-Level Sport Guided By An Ecological Dynamics Framework. Sports Medicine – Open. 2020;6:27. [PMID: 32797290] [PMCID: PMC7427670] [DOI]