

Training in young athletes: Ecological dynamics approach

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ABSTRACT

Background: Ecological dynamics theories provides a multidisciplinary analysis of the processes involved in skill acquisition, suggesting that the relevant scale of analysis for the comprehension of the learning process is the constrain athlete–environment interactions. **Purpose:** The aim of this study is to investigate the experimental experiences of implementation of the ecological dynamics approach in the training of young athletes. **Methods:** A comprehensive search of three databases of literature (PubMed, EBESCO (Sportdiscuss), Web of Science, BASE, Scopus and SpringerLink) from 2010 through 2020 was undertaken. A standard data extraction template was developed to extract the main details for every eligible study. **Results:** In this study were included 17 articles, 16 of which were experimental and 1 quasi-experimental. All studies were conducted with a sample composed on average of 32 ($M = 31.72$) subjects aged between 6 and 21.02 years (mean age 12.2 years). The ecological dynamics approach has been tested in 10 sports. **Discussions and conclusions:** An area in which it is possible to draw conclusions about the didactic effectiveness in the manipulation of specific constraints is in the training of young tennis players. As for the trial carried out in other sports it is not possible to draw conclusions but only suggestions relating to different didactics variations of the implementation of this pedagogical-didactic methodology. Longitudinal studies, with baseline assessment, training and post-training assessment are needed to improve examine the causal relationship between constraint manipulation, learning and motor performances in different sports.

Keywords: Didactic approach; Learning; Sports skills; Training; Coaches.

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INTRODUCTION

The ecological dynamics approach is founded on dynamical systems theory and ecological psychology, integrated in an ecological dynamics' rationale (Ramos et al. 2020). Ecological dynamics suggests that the relevant scale of analysis for the comprehension of the learning process is the person–environment relationship (Davids et al. 2015; Girelli et al., 2019; Alivernini et al, 2019). It promotes a learner-centred approach and presupposes that effective learning depends on a distinctive, unique interaction between the person, the task and the environment (Girelli et al, 2018a). As with experiential learning, this approach emphasizes action and reflection in the learning process (Girelli et al., 2018b). Ecological dynamics has become prominent in explanations of how people acquire movement skills (Brymer & Davids 2014). This particular pedagogical approach is predicated on the notion of a learner as a non- linear dynamical system. It also is applied in therapeutic field with positive findings (Battuello et al., 2012; Rocco et al., 2018; Venuleo et al, 2018). The principles of non- linear pedagogy are based on the key characteristics of non- linear dynamical systems in nature, including self- organization under constraints, emergence and co- adaptation in metastable regions (Rossi et al. 2011). The basis of non- linear pedagogy guides how practitioners might help each individual performer search for functional information movement couplings to satisfy unique constraints impinging during learning (Renshaw et al. 2010).

These insights have also been applied in a non-linear pedagogy for sport, emerging as a viable pedagogical option for coaches in sport. In another context, this approach has been used with high school students to measure their positive attitudes towards doping, the effectiveness of self-regulation and moral disengagement, thus helping teachers and health professionals to predict use of doping by young people or intentions to use doping in the future (Girelli et al, 2020).

One of the most representative didactic models of the dynamic ecological model is the constraint-led approach (CLA). The CLA articulates that through the interaction of different constraints - task, environment, and performer – a learner will self-organize in attempts to generate effective movement solutions (Renshaw et al. 2019). Task constraints are the most important constraint for sports coaches, as they are the easiest to manipulate as part of their practice (Tan et al., 2012). Task constraints include instructional constraints, rules of the sport and any modified rules added on by the practitioner, modifications of equipment such as racket sizes or ball size or composition and other infinite hypotheses and combinations of them (Buszard et al. 2016).

In scientific literature there are numerous authoritative papers and books of an argumentative nature that support CLA as a pedagogical-didactic methodology with a very high potential for success in the processes of teaching and learning, both motor skills and sports techniques (Davids et al. 2013; Renshaw & Chow 2019; Button et al. 2020). This evidence is supported by a relevant literature related to scientific theories of different areas of research, which in a synergistic and complementary way, define a multidisciplinary theoretical framework of very high scientific value (Celia, 2020; Cozzolino, et al., 2017; Cozzolino et al, 2020a; Cozzolino et al., 2020b). On the foundations of these solid theoretical basis, it is essential to understand the pragmatic declination of CLA approach and, in particular, which sporting contexts it has been tested, what methodologies and what outcomes from the point of view of the learning of task, techniques and of sports strategies.

It is also interesting to understand which sports are most tested and whether the results are more promising in situational sports where there is a greater component of open skills or in non-situational sports with a

predominant component of closed skills. Finally, it would be interesting to understand which task constraints has been most experienced and for which sports skill.

METHODS

Selection of the literature

During November 2020, a comprehensive search of three databases of literature (PubMed, EBESCO (Sportdiscuss), Web of Science, BASE, Scopus and SpringerLink) from 2010 through 2020 was undertaken. The principal search terms were as follows: (1) “*Ecological Dynamics Approach*” (2); “*Constraints-Led Approach*” (CLA) and (3) “*Sports*”.

Inclusion criteria

A predetermined set of inclusion criteria was used to select papers for this systematic review. Each study had to meet the following criteria:

- (1) been published between 2010 and 2020.
- (2) it had to include a population of at least 10 subjects.
- (3) the sample had to include subjects aged between 5 and 25 years.
- (4) the research design had to be experimental or quasi-experimental.
- (5) the focus had to be on experimenting with the ecological dynamics approach (CLA) in sports.

Data extraction and reliability

A standard data extraction template was developed to extract the main details for every eligible study in terms of author, title, objective, sample size, design, year of publication, age of participants, reference sport, materials and methods used, results, search engine used.

RESULTS

Title Authors / Year	Sport Sample Age	Materials & Methods	Results	Comments
A principled approach to equipment scaling for children's sport: A case study in basketball Gorman et al. (2020)	Basketball N: 13 Age: 11.7	Method: 3 vs 3 half-court games using size 3, 4, 5, and 6 basketballs. Hand measurement: hand span and hand length. Likert scale to express preferences in relation to the size of the ball.	Hand size / ball size ratio: - no significant difference between size 3 and 4 basketballs; different values for basketballs of size 5, 6, and 7. -no significant statistical difference in preference rating between 3/4 basketballs and 5/6 basketballs, even if the Likert scale data showed greater preferences for 5/6 basketballs. -the size of the basketball for the game most appropriate for junior players (11 years) is 3/4.	Previous experiences seem to influence the choice of basketball in terms of size and therefore it is important to introduce scaled equipment during the initial stages of motor learning. Also, when designing junior basketball programs, one should avoid prematurely exposing children to task constraints equivalent to those experienced by adult players.
Autonomy-supportive behaviours promote autonomous motivation, knowledge	Badminton N: 28 Age: 21.02	Sample: experimental group (13) and control group (15). Evaluation tools: 3 checklists (Game	Skill test: - no significant difference between groups in pre-test measures - both groups increased their scores from pre to post-test after the LSD adjustments	CLA positively influenced learning and performance. Both groups showed improvements in skill learning but the experimental group showed

structures, motor skills learning and performance in physical education. Behzadnia et al. (2017)		Performance Assessment Instrument, Learning Self-Regulation Questionnaire, 45 items to investigate the theoretical knowledge of badminton). Data analysis: PASW; ANOVA; LSD adjustments test; MANOVA; η^2 .	test - decrease in the score for both groups between the post-test and the retention test. Game performance: - the mean scores of the experimental group were higher than those of the control group -significant differences between groups in overall game performance. Knowledge structures: - significant effect for time but not for time/group interaction, - in the pairwise comparisons there was a significant improvement between the pre and post-test both for procedural and declarative knowledge. Motivation: - significant effects for autonomous motivation both for time and for the group but not for the time/group interaction.	better badminton skills. CLA positively affects self-motivation, skill learning and performance.
Between exploitation and exploration of motor behaviours: unpacking the constraints-led approach to foster nonlinear learning in physical education Komar et al. (2018)	Swimming N: 20 Age: 19.2	Sample: 3 groups (control group, analogy group, pacer group). Protocol: 16 training sessions. Outcomes measured: performance and motor behaviour (arm / leg coordination). Tools and methods used: cluster analysis, exploration / exploitation ratio, inertial sensors, Continuous Relative Phase.	Exploration / exploitation ratio: more temporary constraints allow athletes to increase the nature and quantity of explorations. -The three groups showed an equivalent improvement in final performance. -The analogy proved to be the most relevant constraint to encourage the emergence of efficient behaviours. -Pacer group exhibited different behaviours than the analogy group and showed an improvement in exploration during learning compared to the control group.	The qualitative nature of the constraint is the most relevant feature that can be manipulated to promote exploratory learning by guiding the athlete within the perceptual-motor work area.
Comparing the constraints led approach, differential learning and prescriptive instruction for training opposite-field hitting in baseball. Gray et al. (2020)	Baseball N: 40 Age: 20	Sample: 4 groups (DL, CLA, PI, and control group). Outcomes measured: performance (OF). Tools and methods used: pre/post/retention test, ANOVA.	Compared to the control group, the PI group showed a significant change in action selection but not in the number of total points. - The DL group showed more points but no change in the number of swings. The CLA group showed significant improvements in	CLA proved more effective than the other methods because it promoted the development of both movement coordination and the perception of affordances for the couples in the opposite field (OF).

			<p>both areas and greater functional variability in contact point control than the other groups. - Significantly greater increase in the number of for the CLA group between pre and post-test. Significantly greater decrease in the number of pull hits for the CLA group between pre and post-test. Significantly greater decrease in swing between pre and post-test for the CLA and PI groups. - Relationship between lateral position and depth of the ball significantly stronger in the post test compared to the pre-test for the CLA group; the DL group also showed a significant change in this relationship.</p>	
<p>Creating Appropriate Training Environments to Improve Technical, Decision-Making, and Physical Skills in Field Hockey Timmerman et al. (2019)</p>	<p>Field Hockey N: 13 Age: 13.2</p>	<p>Method: 12 training sessions. 8 SSG with two halves of 7.5 minutes. Manipulation of the number of players and the characteristics of the playing field. Outcomes measured: performance, rate of perceived exertion. Tools and methods used: notational and GPS analysis, Rate of Perceived Exertion.</p>	<p>-Reduction in the number of players = increase in the number of technical actions and physical needs. -Possession game = increased passing and decreased dribbling and tackling. -Two-goals game = increase in goals compared to the classic match. -Cage hockey game = increased passes and physical demands compared to the classic match.</p>	<p>Changing the characteristics of the task promotes a change in play behaviour and skill development.</p>
<p>Equipment modification can enhance skill learning in young field hockey players Brocken et al. (2020)</p>	<p>Field Hockey N: 102 Age: 7/9</p>	<p>Two groups of 7- to 9-year old received 4 training sessions with the modified ball followed by 4 training sessions with the regular ball. Group A trained with the modified ball in the first intervention period and group B in the second intervention period. In</p>	<p>-The analysis of variance showed a significant main effect of time and a significant interaction effect between time and group. -Post hoc tests indicated that there were no differences between groups at the pre- and post-test. However, group A performed significantly better in the intermediate test.</p>	<p>Results show that practice with the modified ball led to greater performance improvement than the intervention with the regular hockey ball. The findings indicate that by using modified equipment, sport trainers and physical education teachers can, presumably through enhancement of movement variability during practice,</p>

		a preliminary, intermediate and post-test, participants dribbled an obstacle parcours with a regular ball.	-Between the intermediate and post-test only group B showed significant performance improvements. - Analysis showed that hockey experience was a significant predictor for the pre-test.	stimulate skill acquisition in young children.
Evaluating a 12-week games-based training program to improve cricket batting skill. Connor et al. (2016)	Cricket N: 16 Age: under 15	The experimental group participated in activities with manipulated rules, equipment, and outcome goals, while the traditional group focused on optimizing technical batting skill processes. An analysis of variance was used to examine between and within group differences over time.	The experimental group (CLA) demonstrated an increased number of successful scoring shots, and increased number of runs scored, and an improvement in the quality of bat-ball contact after intervention, while there was no change in the number of attacking strokes played. These numbers were significantly greater than those for the traditional group, which revealed no changes in the number of successful scoring shots played, the number of runs scored, the quality of bat-ball contact, or attacking strokes played.	Skilled U15 players significantly improved facets of their batting using a games-based training approach, while a more traditional training approach did not lead to improvements. Using a constraint-led approach to training fosters overall hitter development.
How manipulation of playing area dimensions in ball possession games constrains physical effort and technical actions in under-11, under-15 and under-23 soccer players. Nunes et al. (2020)	Football N: 52 Age: 10/14/21	Participants performed in a series of 4-a-side SSCGs on different playing area dimensions: small playing area (S), Medium playing area (M) and Large playing area (L). The 4v4 SSCG was performed for 4 sets of 4 minutes each, with 4 minutes of active recovery. Three training sessions were completed on three different days for each age category, with each session being played on the same playing area. Tools: GPS, Zepp's computer software, Borg Scale CR10 to evaluate RPE,	Results showed higher values in the large playing area for under-11 in the distance covered in different speed zones, sprint number and RPE for under-15 in sprints number and maximum sprint speed, and for under-23 in both RPE and sprint numbers. Although no significant differences were found on technical actions, it was still possible to notice some effects through pairwise comparison. High intensity running was promoted on larger playing areas, where under-11 s were also able to perform more technical actions of passing. Opposite, under-23s were able to perform more passing on smaller playing areas, where under-11 s perceived the exercise	To summarize, the findings from this study suggest how coaches can use space manipulation in SSCGs as an important task constraint to shape players' performance behaviour across different age groups. High intensity running proved to be facilitated using larger playing areas, especially for younger players. The findings suggest that coaches should carefully design and monitor the impact of high intensity exercises, given that playing area manipulation presented a differential effect on the internal perception of workload across age groups. Space manipulation during SSCGs should also be considered as a major task constraint

		ANOVA to evaluate differences in performance variables for each age group according to playing area dimension.	more intense. The impact of different playing areas was for the under-15.	to facilitate and shape skill adaptations and development in learners. The use of smaller playing areas seems to favour the increase of passing actions in older players while, in turn, increases in playing area appear to alter the available time for younger players to practice skills without the major constraint of pressing. Interestingly, we also found a reduced impact of playing area manipulations on the different dependent variables for the U15 age group.
Increasing tactical complexity to enhance the synchronisation of collective behaviours: An action-research study throughout a competitive volleyball season. Ramos et al. (2020)	Volleyball N: 15 Age: 14/15	Fifteen youth volleyball team players were studied across three action-research cycles, with performance in one competitive match analysed per cycle. Team synchronisation tendencies were assessed using the cluster phase method, with a 3 (matches) x 2 (set moments) x 2 (court direction).	Results revealed a reduction in team synchrony levels when tactical complexity of counterattacking play increased (second AR-cycle). Nevertheless, similar levels of team synchrony emerged between the first and third AR-cycles. Results also revealed the final moments of a set as a significant environmental constraint that shaped synchronisation tendencies.	Evidence suggested that the (re)achievement of functional synchrony was realised through integration of Constraint-led and Step-Game approaches during practices designed to enhance tactical awareness in players.
Long-term Practice with Domain-Specific Task Constraints Influences Perceptual Skills. Oppici et al. (2017)	Futsal N: 48 Age: 13/14	The orientation of visual attention when controlling and passing the ball was examined in young, elite futsal and soccer players during modified games. The experimental task was a 5 vs. 5 (plus goalkeeper). The scene camera of a mobile eye tracking system was used to collect participants' attention orientation. An external camera was placed in one corner of the pitch to record the task. After	Reception Phase: there was a significant group difference in AL Prior to their first touch, futsal players oriented their attention primarily toward other players relative to the soccer players. The results also showed a small, near significant effect in AS with futsal players switching their attention between ball and players more frequently than soccer players. Control Phase: there was a significant group difference in AT. Futsal players oriented their attention toward other players for a longer period	In summary, despite performing the same skill (passing action), futsal and soccer task constraints shaped athletes' perceptual skills. Higher game intensity, higher opponent pressure, an easier-to-handle ball, and a lower number of players in futsal led futsal players to acquire information on other players' behaviour just prior to and during ball control. On the other hand, a higher number of players, lower game intensity and an unpredictable ball behaviour in soccer led soccer players to scan the

		a standardized, 10 min warm-up, each group was randomly divided into two teams of six players including a goalkeeper. Before each task, two participants were fitted with the Mobile Eye.	than soccer players. Team Phase: there was a Soccer players oriented their attention toward other players longer than futsal players. There was also a significant group difference in AS. Soccer players alternated their attention more frequently between ball and players than futsal players. Game Dynamics Data: There were significant group differences in reception time, in IPA, and in technical intensity. The results showed a higher game intensity in futsal with more passes per minute performed, shorter time to organize the controlling action and lower IPA relative to soccer.	environment when not in possession of the ball.
Modifying equipment in early skill development: a tennis perspective. Buszard et al. (2014)	Tennis N: 80 Age: 6/8	This was a quantitative repeated-measures design experiment. Children were required to perform a forehand hitting task using each of 9 combinations of tennis racquets and balls. Children's hitting performance was measured using a points system. Children must score as many points as possible. Hitting technique was measured via video.	Hitting performance was best when the smallest racquet combined with the ball with the least compression was used. The ball with the least compression also promoted 2 technique benefits: swinging the racquet from low to high and striking the ball in front and to the side of the body.	This study demonstrated the benefits for young children playing with scaled racquets and low-compression balls. The findings are discussed with regards to their relevance to theories of skill acquisition.
Scaling sports equipment for children promotes functional movement variability. Buszard et al. (2020)	Tennis N: 25 Age: 7/8	Twenty-five children were asked to execute a forehand stroke with the aim of hitting the ball to a target located 10 metres away. Participants performed the task in two conditions – a scaled equipment condition and a full-	Scaled equipment led to superior hitting accuracy and greater temporal stability of the swing compared to full-sized equipment. Scaled equipment also afforded the emergence of a functional coupling between upper arm and forearm movement variability which helped regulate the distance between the	Hence, scaled equipment promoted functional movement variability, whereas full-sized equipment resulted in the freezing of mechanical degrees of freedom. This suggests that children's skill acquisition could be hindered and potentially regress when using inappropriately sized equipment.

		sized equipment condition.	shoulder and the racket. Comparatively there was a lack of coupling when full-sized equipment was used.	
The effect of ball compression on the match-play characteristics of elite junior tennis players. Kachel et al. (2015)	Tennis N: 20 Age: 10	The two types of ball compressions that were compared. 10 boys and 10 girls participated in the study, were stratified into pairs. Each pair played two two-set matches: one with standard compression balls and one with modified balls.	The results showed that the use of the modified ball increased rally speed, allowed players to strike the ball at a lower (more comfortable) height on their groundstrokes and increased the number of balls played at the net. Ball compression had no effect on the relative number of winners, forehands, backhands, first serves in and double faults.	The results of this study outline the benefits of the modified ball during match play (competition) and appear to support modifying equipment to accelerate the learning process.
The effect of equipment scaling on children's sport performance: the case for tennis. Timmerman et al. (2014)	Tennis N: 16 Age: 9/10	Sixteen boys had to perform a 30-min match in four different conditions, where court-size and/or net height were scaled by using a scaling ratio based on the differences in temporal demands between the children and the adult game.	Children hit more winners, more forced errors, played more volleys, struck more shots from a comfortable height and played in a more forward court position when the net was scaled. Scaling both the court and net lead to a faster children's game, more closely approximating what is typical of the adult game. The differences between the typical tennis performance variables recorded suggested that scaling the net led to a more aggressive way of playing. Further, children enjoyed playing on the standard court-scaled net condition more than standard adult conditions.	It is suggested that optimising the scaling of net height may be as critical as other task constraints, such as racquet length or court-size, as it leads to a more engaging learning environment for experienced children.
The effect of equipment scaling on the skill acquisition of beginning tennis players. Farrow & Reid (2010)	Tennis N: 23 Age: 8	The participants' ability to rally and their stroke proficiency were recorded before and after a 5-week acquisition phase. Coupled to these dependent measures were within-practice session recording of hitting opportunities, resultant success, and the affective measure of session happiness.	The participants who practised using a standard ball and standard court (adult constraints) were afforded a significantly poorer learning experience relative to the other ball/court scaling combinations. In particular, the adult standardized intervention group recorded significantly less hitting opportunities on the forehand and backhand side than the scaled-court intervention conditions. The	This study has highlighted the negative influence of employing adult constraints for children learning tennis skills. Task and equipment scaling was found to be a useful vehicle for simplifying the task for the learner while allowing the key information sources within the practice environment to be presented in a perception-action coupled manner.

			decreased hitting opportunities experienced within the standardized adult condition then flowed into significantly poorer hitting success relative to the scaled court groups. The modified ball/scaled court intervention group rated their experience significantly happier than the standardized adult group.	
The influence of rules manipulation on offensive patterns during small-sided and conditioned games in football. Machado et al. (2016)	Football N: 14 Age: 13.8	Fourteen young soccer players performed two different SSCG formats (6v6+Gk): Maintenance of Ball Possession Game (MPG) and Progression to the Target Game (PTG). We used the Offensive Sequences Characterization System (OSCS) and SoccerEye software to analyse offensive sequences.	About the MPG results from the detection of offensive patterns assist in confirming that teams seek to choose a method of attack that prioritizes maintenance of ball possession. Regarding the PTG, manipulated rules influenced the emergence of faster offensive sequences, in which teams seek faster progression, attempting to take advantage of the opposing team's defensive unbalance, thus making more shots.	With this investigation, we concluded that players and teams tend to self-organize according to games rules used in SSCGs. The MPG rules tended to influence the emergence of offensive patterns in the progress of ball possession, inducing positional attacks, with more players participating and using, preferably, side paths. The PTG rules tended to influence the emergence of faster offensive sequences through long passes and individual behaviours.
Variable training: effects on velocity and accuracy in the tennis serve. Hernandez-Davo et al. (2014)	Tennis N: 30 Age:13	The skill studied has been the tennis serve. Thirty young tennis players, divided in two groups, took part in this study. One group practiced in variable conditions and the other group in consistency conditions. Both groups performed 12 training sessions.	The variable practice group improved their accuracy significantly compared with the consistency group ($F_{3.25} = 3.078$; $p = .035$). The velocity of serve increased after training in both groups ($F_{3.25} = 15.890$; $p = .001$).	The practice in variable conditions seems to be effective in improving the performance of the tennis serve.

In this review were included 17 articles, 16 of which were experimental (Farrow & Reid 2010, Buszard et al. 2014, Hernandez-Davo et al. 2014, Timmerman et al. 2014, Kachel et al. 2015, Connor et al. 2016, Machado et al. 2016, Oppici et al. 2017, Koman et al. 2018, Tan et al. 2019, Timmerman et al. 2019, Brocken et al. 2020, Buszard et al. 2020, Gorman et al. 2020, Gray et al. 2020, Nunes et al. 2020, Ramos et al. 2020) and 1 quasi-experimental (Behzadnia et al. 2017). All studies were conducted with a sample composed on average of 32 ($M \geq 31.72$) subjects aged between 6 and 21.02 years (mean age 12.2 years). The Constraint-Led Approach has been tested in 10 sports, in particular 6 studies conducted their research in Tennis (Farrow & Reid 2010, Buszard et al. 2014, Hernandez-Davo et al. 2014, Timmerman et al. 2014, Kachel et al. 2015,

Buszard et al. 2020), 2 in Football (Machado et al. 2016, Nunes et al. 2020), 1 in Futsal (Oppici et al. 2017), 2 in Field Hockey (Timmerman et al. 2019, Brocken et al. 2020), 1 in Basketball (Gorman et al. 2020), 1 in Badminton (Behzadnia et al. 2017), 1 in Baseball (Gray et al. 2020), 1 in Cricket (Connor et al. 2016), 1 in Volleyball (Ramos et al. 2020) and 1 in Swimming (Koman et al. 2018).

Of these, 3 studies (Timmerman et al. 2019, Gorman et al. 2020, Nunes et al. 2020) manipulated the field size using SSG and in the studies by Timmerman et al. (2019) and Nunes et al. (2020) the coaches did not give any kind of feedback to the athletes during the training session. Another 3 studies (Connor et al. 2016, Behzadnia et al. 2017 and Gray et al. 2020) compared CLA with a traditional approach to physical education (PE): Gray et al. (2020) investigated the differences between differential learning (DI) and CLA with respect to prescriptive instructions (PI); Connor et al. (2016) and Behzadnia et al. (2017) compared CLA with a traditional approach. Three other studies have focused on the use of CLA in sports training programs (Koman et al. 2018, Brocken et al. 2020, Ramos et al. 2020), specifically, the study conducted by Ramos et al. (2020) was based on three research-action cycles (R-A), two of which were characterized by the use of a combined methodology between CLA and SGA (Step-Game approaches); Koman et al. (2018) and Brocken et al. (2020), on the other hand, investigated the differences between the use (with different times and methods) of task constraints. Oppici et al. (2017) investigated how perceptual skill underpinning the passing action is influenced by domain-specific practice with different task constraints in futsal. The study conducted by Machado et al. (2016) analysed the influence of rules manipulation on offensive patterns in different Small-Sided and Conditioned Games (SSCGs) in football.

DISCUSSION AND CONCLUSIONS

The analysis of the scientific literature, relating to the experimental studies carried out on the pragmatic declination of ecological dynamics approach, shows that tennis was found to be the sport in which the most trials were conducted. In particular, a total of six studies have been carried out on tennis, five of which have demonstrated the effectiveness of the manipulation of environmental constraints related to size of rackets, ball pressure and net height as part of the training of young athletes with an average age of 8.6 years (Buszard et al. 2014; Farrow & Reid 2010; Timmerman et al. 2014; Kachel et al. 2015; Buszard et al. 2020). Only one of these six studies analysed the effects of variability practice in the improvement of the closed skill of the serve, revealing effective in improving of the performance (Hernandez-Davo et al. 2014). In this specific sport field, therefore, given the agreement of several scientific studies on the effectiveness of intervening on the physical characteristics of sports equipment (net height, size and weight of rackets and pressure of balls) it can be concluded that, in the training of young tennis players, the factors related to the manipulation of the environmental constraint "*sized equipment*" can be considered of proven importance from an educational and performative point of view. Scaled equipment promoted functional movement variability, whereas full-sized equipment resulted in the freezing of mechanical degrees of freedom. This suggests that children's skill acquisition could be hindered and potentially regress when using inappropriately sized equipment (Buszard et al. 2020). The concordance in the conclusions of these studies conducted in the field of tennis highlighted the negative influence of employing adult constraints for children learning tennis skills. Task and equipment scaling was found to be a useful vehicle for simplifying the task for the learner while allowing the key information sources within the practice environment to be presented in a perception–action coupled manner (Farrow & Reid 2010).

In full agreement with the results of studies conducted in tennis field they enter the results of the study conducted by Gorman et al. (2020) in basketball. Even in this trial it was shown how a principled approach using anthropometric measures of the hand can be used to identify the most appropriate basketball size for

junior basketball players. The authors of this study conclude by stating that when designing junior basketball programs, one should avoid prematurely exposing children to task constraints equivalent to those experienced by adult players.

The CLA trial carried out in other sports (Badminton, Swimming, Baseball, Field Hockey, Cricket, Football, Volleyball and Futsal) being quantitatively scarce and experiencing different aspects of CLA, it is not possible to draw conclusions but only suggestions relating to different didactics variations of the implementation of CLA.

The results of the studies examined (Oppici et al. 2017; Connor et al. 2016; Timmerman et al. 2019; Brocken et al. 2020; Gray et al. 2020; Ramos et al. 2020) show how a Constraints-Led Approach contributes to positively increase the results obtained by athletes by promoting the development of coordination of movement and perception of affordance. Furthermore, some studies (Koman et al. 2018, Gorman et al. 2020, Nunes et al. 2020) have highlighted that the qualitative nature of constraints is the most relevant feature that can be manipulated to promote exploratory learning. Another very interesting result concerns the study conducted by Behzadnia et al. (2017) which highlighted, through an experiment conducted in the field of badminton, how the CLA positively affects self-motivation, skill learning and performance. A final interesting aspect that emerges from this review of the literature is almost all of the experimental studies conducted so far in the CLA context, except for the study by Komar et al. (2018) conducted on swimming, concerns sports with prevalent open skills.

Longitudinal studies, with baseline assessment, training and post-training assessment are needed to improve examine the causal relationship between constraint manipulation, learning and motor performances in different sports.

DISCLOSURE STATEMENT

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