Chapter

The Development of Motor and Perceptual Skills in Young Athletes

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Abstract

Human movement is a complex phenomenon. For people involved in teaching motor or perceptual skills in sports, effective models of training in children are a major challenge. Topics related to learning and the development of motor or perceptual skills help people involved in learning movements (coaches, physical education teachers, kinesiologists, physiotherapists) to have a deeper knowledge of the learning processes. An attempt is made to combine theory and practice so that this chapter can be a simple but useful tool for learning, evaluation, proper guidance, planning practice, and providing simple practical approaches to make the work of professionals more effective.

Keywords: motor development, processes of learning, training methods, motor skills, perceptual skills

1. Introduction

The purpose of this chapter is to answer the following questions: what are the dimensions of sport expertise? What motor or perceptual skills do athletes usually use in team sports? And what training method should coaches follow in order to make their novices experts? The biggest challenge for coaches, however, is how to keep their athletes motivated, especially children, while creating a positive learning environment, developing motor and perceptual skills, keeping the athletes interested by combining teaching, training, and entertainment, and providing positive training experiences in each training session. All of the above issues should be combined with the fact that each athlete has different abilities [1]. Some important elements that an effective coach should consider are summarized below: utilization of teaching time, organization of the training space, development of positive attitudes [2], and giving the appropriate guidance and deliberate practice - the type and frequency of stimuli an individual receives in order to achieve sport expertise [2]. This chapter opens with an introduction to the preparation and support of the learning experience, before attempting to answer these questions in the main section.

2. Preparing an effective exercise for children

There are situations in which young athletes try to improve their performance of a certain movement or action. All of these situations are referred to as learning experiences and are achieved through targeted, systematic, and organized practice [3].

As we perceive, learning is the interaction between the teacher and the learner, focused on achieving the set goals based on the needs of the trainee, which may change. The effective coaches should prepare their athletes for sports excellence by ensuring optimal, steady performance, improving both physical condition and the technical, perceptual and emotional aspects of training [4].

Initially, the coach should set the goals. The "goal setting" theory was developed by Locke [5], who argued that the coach should set specific and measurable goals individually for each athlete. Locke also holds that goals should be challenging, difficult but not impossible. In addition, the goals should be set in a participatory way, so that the coach can be confident that the trainees are taking the implementation of their goals seriously and are committed to conquering them. Finally, there should be feedback on performance concerning the goals.

In our experience, another very important element that the coach should take into account is the effective use of the training area. The trainer should make sure that an equipped room is available to display videos or photos for the theoretical phase of training where required. There is evidence that the combination of theoretical and practical training is a very effective method for teaching motor or perceptual skills in sports in a changing environment [6, 7]. Some researchers [8–11] investigating methods of practicing perceptual skills used simulation techniques through video projection. The advantages of the simulation techniques are that they can adapt the learning to the personal rhythm of each trainee, they can be used when the athlete is absent from training due to injury or fatigue, they are easily used by people with mobility difficulties, the equipment is cheap and affordable, and they can be applied to all sports. Through the technical simulation, one can adjust the possibilities provided to ensure different training methods. For example, in a picture view, one can emphasize different parts of the visual scene (explicit practice) or block them (implicit practice). Simulation systems and virtual reality techniques will probably soon be used for the basic practice of perceptual skills. Simulation systems provide a seemingly natural racing scene, while virtual reality techniques provide the racing environment through computer units [12]. Using virtual reality systems, perceptual skills can be developed, even in beginners, because they are not bound by the technique of movement. These systems provide precision in movement and are recommended for practicing both motor or perceptual skills.

The level of difficulty of the exercises should be suitable for every athlete in order to ensure a success rate. The exercises should be difficult but also achievable, keeping the self-efficacy of the athletes at a high level. Lewthwaite and Wulf [13] stated that several studies of novice, experienced, and expert performers [14] demonstrated the impact of a sense of success on subsequent performance. Previous achievements in sports performance establish a sense of self-efficacy [15, 16]; and previously positive outcomes give rise to positive expectations for future successful performances [13]. Self-efficacy is described by Bandura [15] as the belief and judgment which a person has regarding their ability to execute specific actions relative to the achievement of specific outcomes. Generally, individuals with high levels of self-efficacy attempt new performances in future trials, expend their effort on these performances, and commonly display increased success in future motor skills [17]. Self-efficacy may be a prospective predictor of motor performance [14] and learning (retention and/or transfer of skill) [18]. The positive effects of self-efficacy on performance in sport and exercise settings are well established [19]. The early development of self-efficacy beliefs is very important, especially for beginners [20]. There is a clear relationship between perceived mastery of performance and feedback in motor performance with self-efficacy [19, 21, 22]. Several researchers [23] have investigated the effect of different instruction programs by differentiating the level of motor skill performance, showing that guidance and deliberate practice - the type and frequency of stimuli an individual receives to achieve sport expertise - play an important role in the improvement of sports performance. When the levels of effort and success are high, then the interest of the athletes is also kept high. When there is success with little effort, then the exercise is considered easy. On the contrary, when the effort is great and there is no success, then the exercise is considered very difficult. Finally, when the effort is small but there is no success, then the interest of the athletes is not maintained.

Finally, skills presentation techniques, i.e. verbal instructions, and demonstration are used to help trainees gain execution knowledge for the desired movement. Oral instructions provide essential information for learning. They describe the skill, the result, the knowledge, the motivation, the attention, and the interest, and they clarify the goals (technique - result, accuracy - speed). Oral instructions should be specific, e.g. "look at the ball." They should also be limited in number, not providing information every time but one piece of information at a time, and need to be repeated due to the limited capacity of memory and attention. Coaches should also direct the athletes' attention to the appropriate key points of the skill. Finally oral instructions should be provided before or after execution but not during execution. The coach should provide information to all athletes. When the skill is easy, they should move among the trainees and make corrections. But when the skill is difficult and the athletes are novices, they should use demonstration (for example by showing videos of the correct performance by expert athletes). Information is more easily conveyed by visual demonstrations than by verbal instructions. The demonstration also helps the trainee to develop the ability to detect and correct mistakes. Trainees should have a good viewing angle and the coach should direct trainees' attention to key points. There is evidence that when beginners watch others perform the skill, they learn faster. The demonstration technique can be used by the coach to demonstrate the technique or part of the skill. This method can be used for both experienced and novice athletes and can be done either at the beginning or during training [24, 25]. It is most often used in complex movements and at beginner learning levels. In order to be substantial, feedback should be specific and not general; it should be positive; as an example after the proper performance, it should be corrective and only individual, otherwise it creates frustration and fear of failure; the ratio of positive and corrective feedback should be 4/1; and pointing out errors should always be accompanied by correction instructions.

3. Development of motor and perceptual skills

3.1 The dimensions of sports expertise

The efforts of researchers and coaches are intended to discover the most effective methods for athletes to achieve the best possible result, performing the optimal movement. Starkes [26] defined athletic excellence as constant outstanding performance over an extended period, defining four key areas: a) the physiological, b) the kinesthetic coordination and technical execution, c) the perceptual, and d) the psychological.

a. **The physiological field** refers to the individual components that constitute physiology and include specialized factors such as strength, aerobic and anaerobic capacity, muscle type and muscle fiber distribution, body morphology and size of each body part, height, flexibility, and general esthetics [27]. The physiological aspect of performance is common to sports, although it varies depending on the nature of each sport. For example, the physiology of speed runners differs from that of endurance runners. There is evidence to suggest that certain physiological factors such as body morphology and muscle fiber type may change after regular training [28]. However, sports physiologists agree that the degree of human adaptation to the environment is indeed limited, the limits imposed are primarily genetically determined, and heredity plays a decisive role, meaning that improvement is limited [29, 30]. Hereditary predisposition to physiological traits appears to significantly limit factors that affect athletes' performance. However, researchers argue that even if the best physiological traits are hereditary, this is not sufficient for high sports performance [31].

b. **Kinesthetic coordination and technical execution** concern the ability of kinetic execution. The technique of high-level athletes depends on the degree of esthetic-motor cooperation and perception, through which the movement is perfected [32]. Technical specialization and experience refer to the degree of coordination of muscles and senses, through which sophisticated, efficient, and effective ways of movement are expressed [33]. Measurements related to technique in athletic skills include qualitative analyses to assess the kinematic and kinetic motif of movement [34]. Regarding the improvement of the performance of the technique, sufficient data confirm that perfecting the movement is a result of long-term, systematic, and deliberate practice [34]. Over time, athletes acquire motor skills patterns which are highly stable and effective, while movement is characterized by a high degree of automation [35].

c. **Perceptual and cognitive abilities** are crucial, especially in team or dual sports when the environment changes and the movement needs to be adjusted to the upcoming stimuli. The knowledge of high-level athletes can be divided into two areas: tactical/strategic skills and perceptual skills [9]. Tactical skills are related to the athlete's overall strategy in each sport, while perceptual skills are related to selective attention, anticipation, and decision making. More specifically:

   i. **Tactics/strategy skills.** Specialization in tactics is essential for the development of expertise in sports [26]. Knowledge of tactics includes not only the athlete's ability to determine which strategy is most appropriate in each situation, but also whether the strategy can be successfully implemented within the constraints of movement [26]. In addition, specialization in sports tactics is different from that in non-motor activities, in that psychological and technical constraints characterize athletes' strategic choices. The methods used to evaluate the tactics concerned the protocol of analysis and observation of behavior, both in training and on the field [36].

   ii. **Perceptual/cognitive skills.** Perceptual/cognitive skills refer to the ability to perceive and adapt to the environment and include the skills of selective attention, anticipation, and decision making [37]. From a competitive environment full of information, motor behavior requires the decoding of the offered elements from the visual scene, by developing strategies of focusing attention, continuous interaction of short-term memory (working memory) with long-term memory, the ability to translate the decision into a kinetic response, and the ability to flex and modify, if necessary, the original decision at the same time. The methods used to evaluate perceptual skills are usually speed and accuracy. These mainly rely on the value of decoding information derived from perceptual skills and the effective response [36]. Research shows that perceptual/cognitive skills training can start at 12 years old [38].

d. **The psychological field** is divided into two sections: a) emotional regulation and b) psychological skills. Emotional regulation is the athlete's ability to control their emotions. Psychological abilities significantly affect athletic performance [33]. Abernethy and Russell [39] report that experienced athletes are motivated internally or externally, have a greater sense of self-efficacy, are more effective in responding to difficult play conditions, and are better able to match appropriate psychological strategies to play conditions, which allows them to respond more effectively. Their sense of self-efficacy enables them to make effective and appropriate decisions under stress and fatigue [40, 41]. In extreme conditions (e.g. stress), the ability to respond correctly and quickly is not greatly affected, as they experience these situations as positive or even provocative [41].

The development of all the above skills is particularly crucial in team sports with a changing environment in which there are simultaneous requirements for excellent performance in motor and perceptual execution plus the management of psychological burdens (e.g. stress). If we can intervene and improve three out of four factors of athletic success - technical, perceptual, and emotional (considering that the biological factors are inherited) - then it is important to identify the most effective training methods for achieving athletic expertise.

3.2 Fundamental framework of perceptual skills

Choosing the right decision in sports requires adaptable behavior in each game scenario, based on the athlete's ability to solve problems. Many researchers are looking for answers to the question "what information do elite athletes use and by what mechanisms do they choose the motor response that requires accuracy even in short time limits?" The elite athletes who have automated these mechanisms seem to respond successfully and with relative ease to extreme competition situations as if they already know the competition scenario and the opponent's movements. The following is a detailed description of three perceptual skills (selective attention, anticipation, decision-making) that play a key role in sports with changing environments, such as team sports or dual racket sports.

3.2.1 Selective attention

Visual attention plays an important part, not only in team sports in which players have to simultaneously monitor the activities and positions of multiple players, but in sports in general [42]. The athlete is observing a display that contains a target stimulus among a variable number of distractor stimuli. The athlete should select all the sports content key points of the environment to focus their attention on and extract the necessary information from the changing sports environment. Early recognition drives on faster prediction, while efficient processing results in better decision-making and effective response to environmental stimuli [43]. Attention is described as the selection of relevant stimuli and the selective structuring of the field of perception [44]. Research has recognized the significance of attention in sports, and the scientific literature provides numerous findings reporting the predominant attentional capacities of experts compared to relative novices [45]. Based on findings in neuroscience [46], attention can be divided into four distinct sub-processes, all of which differ across individuals to varying extents: orienting attention, selective attention, divided attention, and sustained attention. In a sports context, a) orienting attention may be useful for referees since it refers to following different stimuli and extracting relevant features from the complex surroundings;

b) selective attention may be useful for coaches since it gives the ability to recognize the key feature of a complex technique that needs to be changed for the athlete to be able to perform better on the next attempt; c) divided attention can be useful for athletes since they can divide their attention among all the relevant stimuli of a complex situation and subsequently use this information to improve their tactics; and d) sustained attention may also be useful for athletes since they maintain their attention for a longer period.

Visual attention should be differentiated from visual perception since perceptual processes, except for information acquisition, also include cognitive activities such as attention and memory, as well as motor and affective processes. Therefore, attention seems to be a sub-function of a perception whose role is to select the relevant stimuli from a large number of them to guide actions. Selective attention is defined as when specific stimuli are preferred over others, as opposed to simply orienting attention to single locations [44]. Chelazzi et al. [47] observe that "visual selective attention is the brain function that modulates ongoing processing of retinal input for selected representations to gain privileged access to perceptual awareness and guide behavior" (p. 58). If efficient goal-directed behavior is crucially mediated by visual selective attention, it is important to identify the most effective training models for improving selective attention in novices.

In a sports setting, when athletes are exposed to dozens of simultaneous stimuli, only a small part of the incoming information processes and guides behavior because processing resources are inherently limited [47]. As a result, all the available stimuli compete with each other to gain access for further processing, and the visual system chooses to focus the attention on one or a few stimuli that are more relevant to the task [48]. Selective attention functions via a dual mechanism through which the individual focuses their attention on the most relevant information in terms of the task goal while diverting their attention from irrelevant information which may impact the execution of the aiming behavior [49]. According to the ecological theory, Abernethy, Burgess-Limerick, and Park [50] argue that environmental information is selected through visual flow and guides the movement without the mediation of any cognitive processing. On the other hand, Müller and Krummenacher [43] argue that the development of visual processing models discloses an interchange between the pre-attentive and attentive processes. They stated that "if the output of preattentive processing is assumed to only represent basic visual features so that the essential operations of object recognition are left to attentional processes, focal attention must be directed rapidly to the (potentially) most meaningful parts of the field so that the objects located there can be identified with minimal delay" (p. 392), which seems to be a cognitive process. It is concluded that selective attention could be developed either by specific guidance to the most meaningful parts of the field (which presupposes cognitive processing) or without the mediation of any cognitive processing. Therefore, an important question is which methodological approach can lead to the development of selective attention skills.

3.2.2 Anticipation

The improvement of the anticipation skill is decisive for an athlete's performance, especially in dual or team sports in general, in which the environment is altered and an adaptation of the motor response to the corresponding stimuli is required. Thus, an element of utmost importance for athletic performance is an athlete's ability to anticipate what is going to happen next, analyzing stimuli from the surrounding environment to make accurate and quick decisions [37], based on declarative and procedural knowledge. Loeffler and colleagues [51] suggest that three practices are mainly used to evaluate the anticipation skill: a) temporal occlusion (e.g. a handball penalty is occluded at three different time points), b) spatial occlusion (e.g. selected body areas of a penalty-taker or the ball are removed/presented in isolation), and c) point-light display.

According to Cañal-Bruland, and Mann [52], there athletes use two types of information source to anticipate the next action: a) kinematics of the opponent and b) non-kinematic (or contextual) sources of information. The efficient pick-up and use of information emanating from these sources may be governed by different factors related to domain-specific (visual and/or motor) expertise. Kinematic information relates to the key points in the body or the movement of the opponent. The non-kinematic (or contextual) information includes, for instance, tactics, the opponent's position in the court [53], or knowledge of action preferences [54] or sequences of action outcomes [55].

According to Williams, Ward, Smeeton, and Allen [56] there are two types of anticipation in sports: a) related to what is going to happen in the environment, for example when the driver of a car anticipates that the driver in front will turn left. This type of anticipation is referred to as "spatial" or "event" anticipation. b) Predicting what is going to happen in the environment allows the driver to plan their movements in advance so that when the event occurs they expects to be able to start their response faster (in a much shorter time than the usual reaction time). This type of anticipation is known as "time anticipation". It is important to anticipate what is going to happen so that the right moves are prepared in advance [56].

Anticipation depends on the effectiveness of the collaboration between working memory and long-term memory [56]. For this process to take place quickly and accurately, a knowledge base is required, which includes declarative and procedural knowledge. French & McPherson [36] point out that the structure of knowledge in open ball sports consists of two distinct levels: the micro-level and the macro-level. The micro-level refers to what knowledge is required (declarative knowledge) during the performance and depends on the degree of involvement of the working memory. This kind of knowledge is directly related to the visual focus strategies developed by the athlete and the ability to anticipate. The macro-level refers to the action plan (procedural knowledge) and the recognition of the current racing scenario. Spatial and temporal anticipation skills bring a strong advantage in performing various skills. But if the anticipate can predict correctly in both ways, the advantage becomes even greater [36].

3.2.3 Decision-making

In most team sports, an athlete's successful performance depends on both proficient control of movement and the ability to make effective decisions about motor responses. The necessary behavior consists of a creative decision-making in which both accuracy and speed are at top-level [57]. Performers use certain kinds of decision, such as anticipating the direction of a movement, recognizing which repetitive patterns of play strategy are used by the opponent, or identifying certain movement characteristics associated with different responses [58], based on declarative and procedural knowledge. Also, in this phase, the information related to the stimulus is recalled from memory and the information related to the response to the stimulus is activated. This information may be previous responses to a similar stimulus. Some researchers believe that in this phase the image of the response is created, which contributes to the execution of the response [59]. Finally, a series of facts allows the individual to choose the appropriate answer from several possible choices. For example, a basketball player has to decide whether to pass the ball to a teammate or not. Such decisions are very important both in sports and in everyday life, e.g. in driving. Making decisions in the laboratory is evaluated by measuring the reaction time and the accuracy of the answer.

Making the right decision in sports requires both the perceptual and the motor behavior to be adaptable to different scenarios, based on the athlete's ability to solve problems. In a competitive environment full of information, sports performance requires the data provided by the visual setting to be decoded, through the development of strategies for selective attention, continuous interaction with memory, the ability to transform the decision into a motor response, and finally the ability to modify the initial decision in time if necessary [60]. One characteristic of elite athletes in making a decision is the ability to quickly and accurately use the information collected by the visual system and combine it with the information in long-term memory. The cognitive mechanisms which are capable of retaining crucial data in an active state for use in ongoing tasks are defined as working memory [61, 62].

Another issue related to and influencing decision-making is the concept of "complexity". In many sports, athletes have to deal with the temporal or spatial constraints of the environment. As Raab [62] observes, complexity is defined as an environmental complexity, and is operated by changing the amount and connectivity of offered information. Other elements that create complexity are using dual tasks [63], transferring tasks [64], and adding situational factors such as time pressure or emotional stress [9]. Additionally, complexity is linked with the demand to process both a decision and a movement in close succession or even concurrently [65]. Thus, working memory is a system not only responsible for the storage of useful information which is used in the decision-making process but also for mechanisms of cognitive control and attention [66], which makes the concept applicable to complex behavior. For novice athletes, the simultaneous execution of a movement and decision-making causes working memory overload and may therefore cause a disruption in motor performance [67]. To all these elements of complexity are added the tactics of each sport. Raab [62] suggests that in tactical decisions, varying the number of choices and attributes is a useful means of manipulating the cognitive complexity of a situation. For perceptual manipulations, space–time parameters (e.g. distances and moves of players) can also be varied.

3.3 Effective training models for the development of perceptual or motor skills

The development of perceptual skills is very important for sports with open skills, in changing environments where athletes have to quickly and accurately select which stimuli to concentrate their attention on [7]. Comparing experts and novices, several researchers have shown that experienced athletes have more efficient cognitive and perceptual processing mechanisms than novices [60]. Experienced athletes are usually able to extract and process large amounts of information faster and more efficiently from a visual presentation in their specific field of specialization, rather than other irrelevant visual stimuli presented to them [68]. A critical skill of sports athletes is whether they can analyze, select, and pay attention to the useful information of the sports setting and ignore the non-useful information. Subsequently, how are experts able to predict the upcoming stimulus or movement of the opponent and make the right decision? Some researchers have compared how experts and novices pay attention to feint or non-feint actions, concluding that experts outperform novices in inferring the true action intention of the opponent [69]. The question that arises is how to develop the perceptual skills of novices to efficiently select and pick up the most relevant information of the sports setting, anticipate the sports scenario, and make a fast and correct decision. Which learning mechanism is most effective for the development of perceptual skills in novices?

Childhood is an important and sensitive period for cognitive development; however, there is limited research on the methods of development of perceptual expertise in children [70]. Many training programs have been designed and tested to improve perceptual skills in different sports, and results have shown that it is possible to acquire perceptual skills with training sessions both in the field and the laboratory [71]. In a review, Memmert [44] reported that attempts to manipulate selective attention include approaches that direct the visual search to important "information-rich areas" through visual (attentional cues) or verbal (instructions) hints. The training methods/models recorded in the bibliography use training protocols either on the field or in the laboratory, or a combination of laboratory and field.

3.3.1 Training models based on the process of consciousness

Magill [72] suggests that perceptual skills can be improved via two training models based on the process of consciousness: a) using conscious practice models such as explicit training methods, in which the perceptual-motor problem is addressed consciously and with the contribution of working memory to create declarative knowledge [73], or b) using subconscious practice models such as implicit training methods, in which the perceptual-motor problem is addressed subconsciously without the involvement of working memory to create procedural knowledge [74]. More recent studies in the motor learning literature have provided evidence on the crucial role of working memory during the learning process, and even now there is a controversy concerning the different effects of traditional-explicit instruction versus the implicit or analogy methods for the acquisition and retention of sports skills [10, 75–79]. Many researchers argue for the role of unconscious (implicit) processing in learning motor skills [75, 78] or perceptual skills [6, 80] as opposed to conscious (explicit) processing [10, 77, 81].

The explicit learning method is the most common training method used by coaches especially for novices [2]. Through explicit practice, focusing attention on the key points allows the athletes to recognize the appropriate stimuli, analyze them, and process them for the correct response [81]. In this mode of instruction, the coach sets out clear rules and gives verbal instructions on how to execute a particular movement or skill. The acquisition of knowledge via the explicit learning process results in consciously accessible declarative knowledge that can be articulated [82]. Beilock and Carr [83] argue that novice performance is based on explicit, declarative knowledge that is held in working memory and monitored in a step-by-step approach. Muller and Krummenacher [43] note that the allocation of attention can be initiated either consciously or unconsciously, suggesting that guiding attention explicitly to the information-rich points may have a positive effect on the final goal of the task. Explicit learners also develop meta-knowledge (knowledge about our knowledge) about their sports ability [84]. Access to meta-knowledge apparently affects the individual's self-confidence or self-efficacy and could become a factor of success or failure in sports [8]. However, it has been shown that the explicit use of rules places a heavy load on working memory resources. These limitations, under some conditions, will impede learning, since working memory is extremely limited in both capacity and duration [11]. However, explicit learning is not a necessity in the initial phase of learning, since automatic, smooth, effortless, and fast control of goal-directed movements can also be acquired implicitly [85]. Although the explicit model may be effective in improving the movement form, it has been criticized for the loss of the contextual nature of the skills in open sports.

In the implicit learning method, the coach does not give rules of execution but distracts the attention of the trainees using a secondary stimulus [81, 82, 86], in order to develop procedural knowledge, bypassing working memory processing [9, 87]. Ewolds and colleagues [88] argue that in implicit learning the input information directly determines the output of the movement, without the use of attention, and without leading to conscious awareness. Thus, motor skills that are learned implicitly are thought to be less reliant on declarative knowledge than skills that are learned explicitly [10] and instead capitalize more strongly on automatic processes [89].

Several researchers have proposed that the implicit learning method is more effective than the explicit because the latter has been associated with distraction of attention during execution, while implicit learning results in limited declarative knowledge, so there is no additional loading to impede automated movement [8–10]. Implicit learning techniques are thought to lower the amount of attention required to acquire and perform cognitive tasks [90]. Many researchers support the beneficial effects of implicit learning on selective attention and visual skill for adults [74, 91]. Moreover, the supremacy of implicit learning over explicit learning is expressed in conditions of psychological pressure [81, 92]. However, some problems arise from the implementation of implicit learning methods, such as the lack of execution rules, which novices need in the early stages of learning [9, 10] and the impracticability of application in the field, due to the second stimulus [93]. According to Masters [9], the use of a secondary task seemed to impair performance, as it imposed on the learners processing demands they were unable to manage. On the other hand, from a practical point of view, it is not easy for sports coaches to use a secondary task when teaching skills in the field. Furthermore, acquiring knowledge with the use of a secondary task methodology may not only be difficult and demanding, especially for novice athletes, but the learner’s intrinsic motivation may also be weakened by the constant deterioration in performance, as there is a decrease in perceived competence [94]. As Masters [63] argues, one way to overcome the practical problems arising from the secondary task and at the same time take advantage of the implicit learning may be the use of analogies via the analogy training method.

The analogy training method is an implicit type of instruction that aids the learning of a new concept by expressing it in terms of a fundamentally similar concept [95]. It provides learners with information through biomechanical metaphors (analogies) that disguise many of the technical rules ordinarily provided by explicit instruction [63]. Thus, analogy learners have less access to declarative knowledge about the movement than explicit learners [8, 96]. In sport, coaches often draw on analogies to help their athletes understand the skill to be learned. For example, a basketball player may be told to put their hand in the cookie jar when shooting, or a golfer may be instructed to swing the club like a pendulum when putting [93]. Swimming coaches may teach their students to “kick like a dolphin” when they learn the butterfly swimming stroke [97]. Previous studies have shown that learning by analogy instructions is more robust than learning by explicit instructions in cognitively demanding situations, such as stress or dual-task conditions [77, 90, 98]. Previous work has compared the implicit to the explicit learning method of tactical decision-making in ball games [62], and explicit to analogy learning, also in tactical decision-making in ball games [93]. Poolton et al. [93] report that analogy learning improved performance in a decision-making task in complex situations, and was better than the explicit learning condition. Liao and Masters [8] compared implicit, explicit, and analogy learning methods for a motor task. They found that analogy learning was more effective than the implicit or the explicit learning method when a concurrent secondary task was added. Additionally, Lam and colleagues [90] suggest the use of the analogy learning method, comparing it with the explicit method for the improvement of a motor skill under pressure. They mentioned that the analogy learning group had less access to the rules about the mechanics of the movements as opposed to explicit learners. Koedijker et al. [99] suggested that analogy learning seems to by-pass the use of working memory early in learning, thus reducing the need for novices to direct attention to the execution of the movements (declarative knowledge), and as a result, the control structures that preside over the performance of the novice might be more procedural than declarative. It also seems that analogy learning combines the benefits of both explicit and implicit learning without the disadvantages of working memory overload of the explicit learning or the implementation difficulties (due to the dual-task demands for novices) of the implicit learning. However, according to the systematic review by Gröpel and Mesagno [100] the results on the effectiveness of the analogy learning methods are "somewhat inconsistent" (p. 15), since some studies report significantly better performance under pressure conditions compared to explicit instructions [8, 90], although others do not find such effects [101, 102].

But what is the role of working memory and how it can be manipulated through instructions? In open sports with a changing environment, such as team sports, the athlete's ability to adjust to the environment and the upcoming stimuli plays a crucial role. The rapid perception and processing of different stimuli which the athletes receive from the environment leads to the shortest time anticipation, then to correct decision-making, and finally to the most appropriate response-reaction [33]. The mechanisms of attention are responsible for selecting the information that gains access to working memory where action plans can be elaborated [103]. Thus, working memory is a system not only responsible for the storage of useful information but also for mechanisms of cognitive control and attention [66], making the concept applicable to complex behavior. Working memory is a cognitive system that holds and manipulates information while performing cognitive operations [104], and is essential in motor learning [105]. When novices learn a new skill, they pass from a cognitive through an associative to an autonomous phase [106]. In the cognitive phase, knowledge is explicit; it is transformed into implicit knowledge in the autonomous phase. Skill acquisition begins with the declarative, explicit encoding of knowledge with high cognitive processing demands, and ends with procedural, implicit encoding in which demands are low. Both declarative and procedural knowledge is crucial to performance in sports which demand high-strategy skills, and the first step is for the athlete to be able to perceptually select the relevant cues from the environment while ignoring the other information. The explicit encoding process culminates in rules that can be applied to future performance, and which are used for adjusting to task variations. It has been shown that explicit use of such rules places a heavy load on working memory resources [11]. When implicit processes are implemented, athletes are less likely to modify their performance according to explicit rules because they are unaware of the mechanisms underlying performance [107]. Baddeley [66] suggests that implicit processes provide the expert with greater resources to carry out other tasks such as decision-making. On the other hand, explicit processes are reliant on working memory to produce declarative knowledge which is accessed by conscious thought, so that the motor system can control movement "online" [11]. It seems that both motor skills [67] and perceptual skills [6, 62, 92] can be learned implicitly without early dependence on working memory. Several researchers have proposed that implicit learning is more effective than explicit in learning motor skills because the latter has been associated with the distraction of attention during execution, while implicit learning results in limited declarative knowledge, so there is no additional loading to impede automated movement [8–10].

Another question is what happens when athletes are pressured by stress, which is the most realistic condition. In competitive sports, when athletes are performing under stress they worry about optimal performance, which occupies parts of the working memory system which is needed for optimal performance [108, 109]. In stressful situations, when athletes are looking for the correct movement execution they try to remember explicit rules and thus they alternate their motor control from an automatic-implicit control to a more conscious-explicit control, hoping that this will ensure correct performance [82]. Masters [9] argues that when motor skills are learned implicitly, without early dependence on working memory, they are less affected in pressure situations since they do not acquire explicit rules to recall them. Several researchers [8–10] also hold that implicit learning is more effective than explicit in learning motor skills, especially in stressful situations, because the latter has been associated with working memory overload during execution, while implicit learning results in limited working memory overload and declarative knowledge storage, so there is no additional loading to impede automated movement. When athletes acquire skills through explicit methods they underperform when placed under psychological stress since they try to recall the rules of execution – a process similar to novice execution [10, 110]. Masters [9] reported this situation as "reinvestment"; according to the reinvestment hypothesis, athletes who learn motor skills through explicit learning methods reduce their performance when they are under psychological pressure because in order to respond they return to the information processing of the initial stages of learning. In this way, they divert their attention from the rich information provided by the environment, while choosing to recall rules and instructions that they have already learned about the skill. Thus, the omission of explicit rules has a positive effect on performance, especially in stress conditions [8, 11]. Van der Kamp et al. [85] explain that this is because "*the liability to the well-known phenomenon of choking is diminished in comparison to explicitly learned movements, which are much more prone to the recurrence of explicit step-by-step monitoring (i.e., the reinvestment of verbalizable rules) as reflected in broken and stuttered movement execution*" (p. 506). Additionally, Davids, Williams, Button, and Court [111] suggest that the implicit learning method can be just as effective as explicit learning, however, the former is better in high-stress situations [8, 10, 93]. Liao and Masters [8] stated that "*If the task does not demand a lot of information processing resources and many spare resources are available, the motivational function of psychological stress may be likely to have a positive influence on performance*" (p. 318).

Moreover, two other theories describe that anxiety consumes the limited attentional resources of an individual, leaving less attentional capacity for the actual ongoing task [112, 113]. According to the "Attentional Control Theory – ACT" [114], anxiety causes a diversion of processing resources from task-relevant stimuli to task-irrelevant stimuli. This impairment and pre-empting of attentional resources leads to a shift in the attentional systems such that anxiety leads to increased reliance on the bottom-up, stimulus-driven attentional system. This is an expansion of Eysenck and Calvo's [115] "Processing Efficiency Theory – PET" which was developed to clarify the link between performance and anxiety used the following two assumptions: i) cognitive anxiety establishes itself in the form of worrying thoughts which influence working memory by reducing the limited attentional resources, thus decreasing the quantity of free attentional capacity to involve in parallel task demands, and ii) anxiety leads to increased cognitive effort and the conquest of additional processing resources.

3.3.2 Training models based on the type of instructions

Wulf [116] proposes that the type of instructions - external rather than internal focus of attention - is the factor that affects the development of perceptual and motor skills. Several studies have demonstrated that manipulation of feedback instructions which induce an external focus by directing performers' attention to the effects of their movements (external focus) rather than their body movements (internal focus) results in more effective motor performance and learning for either movement form or outcome [117]. The external focus provides a subconscious motor control that results in greater movement automaticity compared to the internal focus of attention [116, 118–120]. Chua and colleagues [121] mentioned that training via external focus leads on automatic control processes frees up that system to engage flexible, reflexive movement control processes, and likely enhances functional connectivity of task-relevant brain areas [122, 123]. Chua et al. [121] also note that internal focus is linked with self-related thoughts and increases micromanagement of the intended movement such that learners are more likely to engage in conscious control of their motor system and disrupt automaticity [119, 123]. According to Masters [9], during motor execution, declarative knowledge of "what to do" is usually acquired in the early learning stages, when individuals try to find which response is the most optimal. Cognitive knowledge and conscious processing regarding the components of motor skills have been found to produce poor performance [9, 83]. It seems that the internal learners tried to consciously recall the rules governing the answer, and therefore tended to consciously interfere with the control processes and interrupt the automatic response processes. The theoretical background can be explained by the "Constrained Action Hypothesis" [122], which states that an external focus of attention promotes a more automatic type of control and allows the motion system to take advantage of unconscious and rapid control processes. Instead, an internal focus may lead to a conscious type of control, causing learners to restrict their motor system by interfering with automated procedures [124]. Poolton and colleagues [125] also suggest that external attention cues, even during the initial stage of learning, reduce the load of working memory. In contrast, internal attention cues increase the load of working memory, which may lead to reduced performance, especially in young individuals.

Despite the consistent evidence in favor of the hypothesis that external focus is superior to internal focus in adults, research on the benefits of internal versus external focus of attention in children is ambiguous [126]. While some studies have confirmed the beneficial effects of external focus in children [123, 127], others showed that the focusing function did not affect children's motor learning and performance [128, 129]. Tsetseli and colleagues [130], found better scores in tennis serving movement form by young athletes who practiced using an external focus of attention than in those who practiced using internal focus. They argue that in studies with more stable (closed) environments, no differences were found between the internal and external attentional focus group, in movements such as golf shot [116] and soccer kick from a fixed ball position [131]. This may lead to the conclusion that instructions directing the attention externally may be more effective and beneficial for open skills [130]. It is worth highlighting here that directing attention to the task goal (hitting the target) bridges the gap between goal and action [132]. Peh et al. [133] conclude that an external focus of attention has a different impact on different stages of learning, while Singh and Wulf [134] suggest that both internal and external focus of attention are different according to the level of expertise. Becker and Smith [135] suggest that attentional focus affects children and adults similarly, but task complexity moderates these effects. An et al. [136] conclude that both movement form and outcome are enhanced in complex skill learning by providing learners with relatively simple external focus instructions.

Another explanation for the superiority of the external over the internal focus of attention is provided by the "Optimal Theory" [123], in which external attentional focus conditions are presumed to facilitate functional connectivity, that is, task-specific neural connections across distinct brain regions that are seen in skilled performers [124, 130]. Lack of a clear task focus (internal focus) would impede switching to task-related functional networks or goal-action coupling [137]. The external focus directs to an unconscious control process, directs movements with relative clarity toward the action goals enhancing goal-action coupling, and promotes automaticity [122, 123]. By directing the concentration away from the body and to the desired effect of the movement or the target, external focus favors the establishment of effective neural connections that are critical for optimal performance. The result is an effective movement pattern and improved learning and performance. Ghorbani and colleagues [137], who support the "Optimal Theory", propose that the adoption of an external focus of attention directs the attention on target, successfully and perhaps more beneficially to young athletes [124]. Moreover, it is well established that external focus enhances neuromuscular automaticity, increases task goal orientation [121], reduces cognitive load [138], and alleviates performance anxiety [124].

4. Conclusions

In this chapter, an attempt has been made to answer the following questions: what are the dimensions of sport expertise and what training methods is it suggested that coaches use in order to make their novices experts (perceptually or kinetically)? The conclusions are summarized below:

Starkes [4] defined athletic expertise as constant outstanding performance over an extended period, defining four key areas: a) the physiological, b) the kinesthetic coordination and technical execution, c) the perceptual, and d) the psychological. The development of all the above skills is particularly crucial in team sports with a changing environment in which there are simultaneous requirements for excellent performance in motor and perceptual execution plus the management of psychological burdens (e.g. stress). If coaches can intervene and improve three out of four factors of athletic success - technical, perceptual, and emotional (considering that the biological factors are inherited) - then it is important to identify the most effective training methods for achieving athletic expertise.

The researchers propose effective training models for the development of perceptual or motor skills a) based on the process of consciousness, and b) based on the type of instructions.

a. Training models based on the process of consciousness: Compared with the explicit method or the rest of the implicit methods that divert attention, analogy learning seems to produce better outcomes and ensure more stable performance in the long run and under stress conditions. Explicit training drives trainees to a working memory overload, resulting in delayed and wrong answers, and making them underperform dramatically in stressful situations. Even though the explicit method is the most common, analogy learning is recommended because it contributes to both accuracy and speed of decision-making and skill learning under normal and stressful conditions. Learning by analogy is practicable in the field, and could be applied instead of methods that rely on the use of explicit instructions. The use of simple analogies may support the implicit development of athletes' skills without disrupting their performance. Nonetheless, it is coaches who face the greatest challenge: they are the ones responsible for coming up with effective analogies, which will comprehensively integrate all the necessary technical structures for a new skill to be learned and performed. Although this entails certain difficulties, the overall advantages implicit learning has to offer compared to explicit learning seem to promise a favorable outcome. Further research is needed to expand our knowledge on the implementation of analogy learning in other perceptual skills, in both simple and complex situations, in different sports as well as in different contexts and domains, such as production, the military, or medicine.

b. Training models based on the type of instructions: The positive effects of external vs. internal attentional focus for motor skill learning have been proposed by many researchers. Since both methods improve movement form and outcome, the decision of where to focus may not be a matter of what is right or wrong, but rather which is better under certain circumstances. Instructors should consider that effective sport skill learning occurs using either an internal or external attention focus depending on various factors, including whether the skill is open or closed, as well as the preferred attention focus of the participant. The adoption of an external as opposed to an internal focus of attention leads to the enhancement of motor learning and performance, and promotes participants' focus on the goal. It seems that directing attention to the task goal (hitting the target) bridges the gap between goal and action. It is concluded that an external focus of attention has a different impact on different stages of learning, or at different levels of expertise, while task complexity moderates these effects. It seems that the complexity factor might interact differently with the attentional focus factor for movement form or movement outcome, and this needs further research.

The biggest challenge for coaches, however, is how to keep their athletes motivated, especially children, while creating a positive learning environment, developing motor and perceptual skills, keeping the athletes interested by combining teaching, training, and entertainment, and providing positive training experiences in each training session.

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