SECTION I

Theoretical aspects of sports performance analysis
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GETTING ON THE RIGHT TRACK

Athlete-centred practice for expert performance in sport

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Summary
In this chapter, we offer guidelines for optimizing practice based on empirical studies of motor learning and a review of various practice methods. In so doing, we tie motor learning literature to developmental models of expertise in sport based on early specialized practice. We attempt to show how increased knowledge of skill acquisition and athlete-centred practice principles can enhance the quality of information provided to athletes for learning. Athlete-centred practice structuring can facilitate learning through the development of technical and tactical competencies, and increase robustness in the face of competition pressures, as well as encourage short- and long-term engagement and motivation. This is broadly achieved through a focus on the development of the athlete as a cognitively engaged problem solver. Knowledge of long-term practice pathways is necessary for practitioners as they work on developing athletes from an early age and as they make decisions concerning how much to practice and when. With respect to skill development, skill transfer and long-term engagement in sport, we argue that early specialized practice designed to promote activities which encourage cognitive effort, problem-solving behaviours and engagement on behalf of the athlete should be seen as the goal of the development of sporting excellence.

Introduction
For a long time, the general perception of the best athletes in the world was one fuelled by language of inbuilt talents and predispositions that were necessary possessions for attainment of success. In the past few decades, in no small part due to the research of Ericsson and colleagues, this view on expert performance has been somewhat de-cloaked. What have almost come to be universally recognized as the most important components to success are the amount and type of practice. This has led to a surge of interest in the discovery of best methods for practice, as well as the optimal practice pathway for attaining elite levels of performance in sports. In the first part of this chapter, we review various practice methods and their implications for skill development and optimization of athlete performance. In the second part, we tie these methods to models of
long-term athlete development and make recommendations for performance analysts based on principles of athlete-centred practice.

**Practice methods**

**Demonstrations**

Demonstrations are perceived as fundamental to skill learning and, in many sport situations, they are considered the most appropriate way of instructing. Essentially, a demonstration provides the learner with a visual template for a desired movement, helps to emphasize key movement features and/or conveys a strategy for goal attainment (Hodges and Franks, 2002). Visual demonstrations are thought to reduce cognitive processing demands when compared to other types of instructions (Newell, 1985). There have been a significant number of reviews showing the potential benefits of observational practice for motor learning (e.g. Ashford et al., 2006; Hodges et al., 2005; Maslovat et al., 2010; McCullagh et al., in press). Although this technique has met with considerable success, below we outline methods which appear to best engage the learner with solving the motor task and avoiding learner dependencies on the coach.

Providing demonstrations *after* a practice attempt, rather than *before* an attempt, encourages the athlete to think and engage in the learning process. ‘Retroactive’ demonstrations provided after, rather than ‘proactive’ demonstrations provided before, function more like feedback and are assumed to aid retention through enhanced cognitive effort and what is termed ‘retrieval practice’ (Richardson and Lee, 1999; Patterson and Lee, 2005). There is some debate as to whether demonstrations in general should be provided early or late in practice. It appears that they are most beneficial when given early in practice then faded out, especially for acquiring new skills. Interspersing demonstrations with physical practice attempts early and during practice also seems to be the best method for promoting motor skill learning (e.g. Carroll and Bandura, 1990; Weeks and Anderson, 2000; see also Ong and Hodges, 2012, for a review).

When performers are given control over when to receive demonstrations, not only do they show better retention and transfer to similar variations of the skill, they also tend to ask for this information on a relatively small amount of trials (about 10 per cent: Wrisberg and Pein, 2002; Wulf et al., 2005). Although there is some evidence that more skilled individuals request this type of information more frequently for practice of new skills (about 20 per cent of trials: Hodges et al., 2011), inhibiting the tendency to show and tell frequently during practice and giving the learner control over when demonstrations in practice are given appears to positively impact learning.

Showing someone what to do might incidentally convey what they should avoid doing. Although this could speed acquisition, in motor learning research there is considerable evidence to show that techniques which might prove best for rate of acquisition and short-term performance gains are not typically the best for long-term retention (see Schmidt and Lee, 2011). Errors in performance are not considered detrimental if the learner is aware of the error and has the tools to correct it. In coordination research, the avoidance of certain types of errors has been shown to negatively impact on acquisition rate and the dispensing of ineffective movement techniques (Hodges and Franks, 2000, 2002).

People also learn from watching incorrect or suboptimal performance, such as watching peer models (e.g. Shea et al., 1999; Shebilske et al., 1992). Seeing a combination of correct and incorrect learning models allows the goals of the action to be accurately conveyed and also encourages the observer to be an active observer, engaging in the problem-solving process needed for
the detection and correction of errors (e.g. McCullagh and Caird, 1990; Rohbanfard and Proteau, 2011). Variability in the types of demonstrations provided also alerts the athlete to other potential solutions for achieving a goal which may be suited to the athlete’s current capabilities, body constraints or practice conditions (such as a muddy field). By directing attention towards a particular model or one ‘correct’ technique, the individual is inhibited creatively and has less chance to vary their practice. With access to video editing technologies, another technique which engages the learner and aids creativity in attaining success is to provide demonstrations that only show the desired outcome effects (e.g. the flight of the ball or the kicking foot in a soccer kicking task requiring the ball to go in the air, e.g. Hodges et al., 2005, 2006).

In summary, demonstrations can promote skill development and engage the athlete if they are provided sparingly, are based on the learner’s perceived needs and engage problem-solving activities through techniques such as learning models or outcome models. In Table 1.1, we have summarized various practice methods and techniques associated with their delivery. These have been subdivided into those we consider to be more athlete- versus coach-centred in terms of the involvement of the athlete in how the practice is structured (i.e. low or high). When the coach directly determines how, what and when activities are practised, showing what to do and continually correcting or preventing errors, then this is considered to be a highly structured coaching environment. In comparison, a more athlete-centred learning environment is one where the learner is actively involved in how to practice and learning what to do, fostering long-term learning, transfer and engagement.

Table 1.1 Summary of various practice variables and associated methods which could be considered to be more athlete-centred (low structure), whereby the learner is actively engaged in the learning process, in comparison to techniques that would be considered more coach-centred (high structure), where the learner is less involved and engaged in practice

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<td>Use of physical/task-constraints</td>
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<td>Feedback</td>
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<td>Coach-chosen amount/when/type</td>
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<td>Variations in practice of one</td>
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<td>Athlete-chosen organization</td>
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Much of what we have said about demonstrations holds for instruction. However, there are a couple of important research findings with respect to instruction. The first is the repeated finding that a learner’s focus of attention has a significant impact on performance and learning. Small changes in the focus of instructions from the body (internal) onto the effects of the action (external) can change how well a skill is acquired and retained (for a review, see Wulf, 2007). In throwing tasks, such as the forehand Frisbee disc throw, internally focused instructions might be ‘accelerate first your elbow and then your wrist’ or ‘lead into the action with your elbow’, whereas an external focus directs the performer’s attention towards the intended effects, such as ‘step into the throw and release the disc as though you are snapping a wet towel’ (see Ong et al., 2010). Directing attention externally can be beneficial for skilled and less skilled athletes, in comparison to internally focused or no-attentional focus instructions, although it appears that instructions which direct attention internally, onto the movement (e.g. the hand in batting or the foot in soccer dribbling), are more harmful for skilled than novice performers, in comparison to other attentional focus manipulations (Beilock et al., 2002; Ford et al., 2005; Gray, 2004). One reason why externally focused instructions work is that they encourage an appropriate level of movement control, one that is directed at attaining the task goal, but not at movement prescriptions and body-related techniques.

Instructions have also been shown to affect performance under pressure. In their work on implicit learning, Masters and colleagues have shown that during stressful conditions performers re-invest attention towards previously learned explicit rules about the technical aspects of an action (for a recent review, see Masters and Poolton, 2012). This re-investment of knowledge can cause disruption in what are regularly ‘automatic’ processes. Under stress or pressure, performance is thought to regress to an earlier performance level (e.g. Baumeister, 1984), which might be more akin to irregular movements characterized during early learning (e.g. Fuchs, 1962; Deschamps et al., 2004). Individuals that exhibit high levels of re-investment have been shown to rely on more explicit information to control action than low re-investors during stressful situations (Masters, 2000; Masters and Maxwell, 2004). Liao and Masters (2002) showed that the greater the number of rules acquired during learning, the poorer was performance under pressure. These pressure costs were most apparent when instructions were internally focused and provided early in practice (Ong et al., 2010). Consequently, learners and practitioners should be mindful of the amount of explicit rules or instructions given during practice. Although a number of methods have been proposed that lead to a reduction in explicit knowledge accrual and disruptions under pressure (e.g. dual-task learning, errorless learning and analogy learning; see Lam et al., 2010, Liao and Masters, 2001, and Poolton et al., 2006), such methods can be hard on the learner, making acquisition extremely effortful and not always as productive as non-instructed or instructional methods, at least for regular tests of retention. However, resistance to psychological pressure (Hardy et al., 1996; Liao and Masters, 2001; Masters, 1992; Mullen et al., 2007) and even physiological fatigue (Masters et al., 2008; Poolton et al., 2007) might be worth the associated slower learning costs, so long as the athletes can remain motivated and engaged.

A theoretical approach which has the potential for decreasing prescriptive instruction and keeping the performer’s attention directed to external features is the constraints-led approach, initially developed by Newell (1985) and adapted to sport by Davids et al. (2008). In the constraints-led approach, a change in movement can be brought about by careful manipulation of three interacting factors: environment, task/goal and person. In addition to the altering of sensory information, such as vision, environmental constraints include field dimensions, playing surface
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and weather conditions. Person constraints refer to the characteristics of the learner, such as stature and psychology. Task constraints are often manipulated by the coach through the adaptation of rules or equipment. Through the interaction of these constraints, learners are directed towards strategies for bringing about movement solutions and/or effective decisions. For example, placing a barrier between a target and a ball conveys to the kicker that the ball has to go up to a particular height. The distance of the target to the ball will also constrain how the ball is or can be lifted (such as a scoop, chip or follow-through kick; see Hodges et al., 2006). In this way, the athlete is guided to a task solution but they are actively involved in deriving the solution. The interactive nature of constraints means that constraining one factor is likely to influence the other. Reducing the dimension of the field of play (environmental) in a soccer possession exercise (task) will likely reduce opportunities in identifying passing alternatives, reduce decision-making time and increase the relative timing of the passing movement (person). In this scenario, players will have to actively seek solutions to deal with the increased temporal demands, such as limiting their touches or repositioning.

One of the key aspects of a constraints-led approach is to set up parameters that are appropriate to the learners’ needs. A greater number of options should be included for advanced learners, while options should be limited for beginners (Schöllhorn et al., 2009). These ideas of matching challenges to participant’s needs, such as the need to acquire a skill and hence have reduced demands, or the need to learn and refine a skill and hence be challenged, are also at the core of the Challenge Point Framework (Guadagnoli and Lee, 2004). In this framework, information is considered a constraint on learning (see also Hodges and Franks, 2004). Careful consideration of constraints should place the learner at the forefront of the learning experience.

In summary, instructions should be provided to engage the learner in the processes needed to learn and retain skills and, importantly, transfer skills to new learning situations (see Table 1.1). Instructions should not be considered the default way of changing a skill and consideration should be given to altering constraints to bring about a movement solution. Given the requirements of athletes to perform under competitive pressures, techniques which reduce the emphasis on explicit, rule-based knowledge will be most beneficial for training.

Feedback

Feedback is information relating to how a skill was performed and its effectiveness. The way feedback is presented and its content can also have significant implications for learning, the engagement of the learner and the skills developed. Some of this information is a naturally available consequence of performing (termed ‘intrinsic feedback’) but often the coach augments this feedback in terms of the success of the action or outcome (termed ‘augmented feedback’). Feedback can promote efficient learning, ensure correct development of the skill and influence motivation to persist with practice (for recent reviews, see Magill and Anderson, 2012; Williams and Hodges, 2005). The most critical finding to underline with respect to feedback provision is the need for it to be provided sparingly. Providing augmented feedback after every trial can accelerate performance. However, feedback itself serves to guide the learner to the correct solution, such that the learner has not learned to perform the action when feedback is no longer available. This developed dependency on augmented feedback is known as the guidance effect (e.g. Salmoni et al., 1984; for recent reviews, see Magill and Anderson, 2012; Wulf and Shea, 2004). Continued and significant provision of augmented feedback reduces the capacity of learners to actively engage in the problem-solving process. Problem solving through error detection (e.g. was there something wrong with my action and its outcome?) and correction (e.g. what do I need to change?) is vital to skill learning as constant augmented feedback is not
possible in competition situations. Individuals should be actively encouraged to develop these problem-solving skills through prediction of what their actions will feel and look like when success is achieved.

Skill level and the complexity of the motor skill affect how feedback should be provided. Early in learning, feedback may be required more frequently (Wulf et al., 1998) and ‘faded out’ over time in order that learners become self-equipped to detect and correct errors. Adopting this technique of giving and then reducing feedback will help provide learners with a basic grounding of the fundamental elements of the skill, arguably developing motivation to continue to practise through competency attainment (Deci and Ryan, 2008). The skill of the coach is to determine the correct amount and schedule of feedback as a means of facilitating learning without negatively compromising the development of the athlete and their ability to correctly interpret intrinsic feedback.

The precision and nature of feedback can also affect learning. Providing individuals with prescriptive feedback about what to do can further reduce the problem-solving activities of learners to a greater extent than descriptive feedback, which refers to what went wrong with the skill (Wulf and Shea, 2004). During tasks that are difficult or during the early stages of learning, participants may require more prescriptive feedback to improve performance and maintain motivation, whereas later in learning the feedback should be more descriptive (Wulf et al., 1998). As tasks become more advanced, or as performance improves, the feedback may need to become more precise in order to match the goals of performance. If performance plateaus, then this is a potential sign that alternative sources of feedback are required to move to a new level. As a general rule, feedback should decrease in its frequency and increase in its precision as skill develops. There should be a progressive shift from prescriptive (i.e. this is what you should do) towards descriptive feedback (i.e. this is what you did do) as a means of developing skills, retention and effective problem solvers.

Providing learners with the choice of when to receive augmented feedback underlines the athlete-centred principle of effective practice. In self-regulated practice, the athlete determines when to receive feedback or the type of feedback. This method has shown to be effective for promoting learning and transfer to new performance contexts (Chiviacowsky and Wulf, 2002, 2005). In a novel throwing task, Janelle et al. (1997) showed that participants who were able to choose when they received feedback about success improved more during performance and retention than a ‘yoked’ group who followed the same feedback schedule as the choice group. Research on self-regulated feedback provides some interesting insights into the preferred mode and frequency of feedback. Self-regulated participants prefer to receive feedback after perceived successful (or low error) trials (Chiviacowsky and Wulf, 2002, 2005). This tendency appears to show a learning strategy that could be thought of as counterintuitive to traditional coaching techniques, whereby feedback is typically provided immediately after unsuccessful or erroneous attempts (i.e. Adams, 1971). Preference to receive feedback after successful trials may facilitate motivation through developing a sense of competence. Therefore, in addition to the information-giving role of feedback, the reinforcing and motivational role of feedback should be highlighted. There is some evidence that more skilled performers seek information rather than necessarily reinforcement (Hodges et al., 2011) but careful study of domain experts with respect to feedback has not been undertaken. This motivational role of feedback for aiding motor skill acquisition has received renewed attention. In one study, it was found that providing participants with ‘positive’ feedback about performance (i.e., informing learners that they were more accurate than their peers irrespective of whether this was true), rather than the reverse or even withholding this information, resulted in improved learning (Wulf et al., 2010). Because the ‘positive’ group outperformed the ‘negative’ group, this is more than just a competition effect,
but rather appears to be related to positive affect associated with affirmation of competency (Lewthwaite and Wulf, 2012).

In summary, augmented feedback is a powerful learning tool if administered in a way that promotes cognitive effort on the part of the learner and if it is delivered positively or provided based on the directions of the athlete. The techniques that best promote this type of learning, which we have defined as low structured, are summarized in Table 1.1.

**Practice organization**

An understanding of the organization of practice conditions is another critical variable in optimizing athlete learning and development. A well-studied practice variable that has shown to be relatively robust among sports and across individuals relates to the variability in the scheduling of practice conditions, referred to as the ‘contextual interference’ (CI) effect. When multiple skills are presented in a variable or random order (high CI), although the rate of acquisition may be slower in comparison to a low variable or blocked order (low CI), in retention tests the reverse pattern is seen. More random practice schedules result in better retention of the skills than more blocked schedules (for reviews, see Lee and Simon, 2004; Lee, 2012). Consequently, coaches and athletes should aim to avoid repetitious blocked practice and instead include a variety of skills within the same session. One exception to this may occur in the early stages of learning when reducing the amount of variability in practice appears to be beneficial to help individuals stabilize a skill (see Guadagnoli and Lee, 2004; Shea et al., 1990). Indeed, this strategy of adopting a more blocked practice in early learning before progressing to a more randomized schedule was spontaneously adopted successfully by expert musicians when learning an unrelated throwing skill (Hodges et al., 2011).

One of the proposed mechanisms underlying the beneficial effects of variations in practice of different skills is related to the idea that it is beneficial to ‘forget’ and ‘recall’ skills from trial to trial so that retrieval processes are strengthened, again promoting strong problem-solving abilities in the athlete. When one skill is continually practised, there is not the same effort in retrieving and remembering what to do. Although practice is easier, retention and transfer are poorer (Lee and Magill, 1985). In addition to practising different skills in a more variable/random order, there are also advantages with practising the same skill under different variations. This might involve shooting skills from different distances or to different targets. Introducing variability into practice trials forces performers into making slight adjustments to their movements and their motor commands, resulting in more adaptable movement patterns particularly suited to dynamic conditions of competition. There has been considerable empirical support for learning advantages associated with variable rather than constant practice conditions (i.e. performing a singular skill with no variations in conditions), particularly for transfer of skills within the range of variations practised (Lee et al., 1985). Variability of practice is based on the idea that experience adapting to different sensorimotor conditions strengthens the representation of movements for the parameters practised (Salmoni et al. 1984).

Somewhat more recently there has been evidence that variability not ostensibly related to the task goal can also facilitate skill learning and retention across different skill levels. The augmenting of error and the encouragement to practice in a manner that leads to variation in the movement technique have shown some promise for aiding acquisition and improvements among new learners and more skilled performers. Error augmentation techniques are based on principles of aiding processes related to the detection and subsequent correction of errors. By making errors larger early in practice (or later), then the learner is forced into determining how to adapt and correct, potentially making them more able to apply these methods when
the errors are reduced (e.g. Huang et al., 2007; Patton and Mussa-Ivaldi, 2004). An additional method which has garnered some empirical support is termed ‘differential learning’ (Schöllhorn et al., 2006). Here, random variability is introduced into training through encouragement to perform variations of a movement from trial to trial, so avoiding repeated attempts to produce a ‘correct’ or desired movement. In comparison to more traditional types of practice, repetition and corrective feedback are avoided. The principles behind this technique are based on concepts of constraints (Davids et al., 2008). Because of the variability inherent in performance contexts, performers need to be able to quickly adapt their actions to fit the current environmental and task demands unique to competitive sport. It is important to find the optimal levels of variability that challenge the learner, but do not overly challenge the learner. However, too much augmented variability can be as bad, or potentially worse, than too little (Edwards and Hodges, 2012), such that the coach and/or athlete needs to be prepared to adapt their training methods to accommodate for differences between individuals and within individuals across training sessions.

As discussed earlier, the athlete might also be one of the best judges as to when they should vary their training. Allowing the learner control over when to switch between practice of different skills has been shown to benefit learning. Keetch and Lee (2007) showed that, irrespective of the overall amount of variability in the practice of three different skills, learners who were allowed to choose the order with which to practise showed better retention than individuals not given this choice. Giving the performer autonomy over the learning environment appears to carry certain advantages over and above those gained from merely varying the amount of feedback, demonstrations or variability. Based on Deci and Ryan’s (2000, 2008) framework on fundamental psychological needs, Lewthwaite and Wulf (2012) argue that this autonomy benefits motivation to learn and improve, leading to intrinsically motivated individuals who participate for the inherent value of the sport and not for external rewards. Again, in Table 1.1, we have summarized these practice organization techniques which best encourage skill development and athlete engagement under the heading ‘athlete-centred’.

**Practice pathways**

As the quality of youth development programmes improve, performance analysis techniques are increasingly employed with younger athletes and teams. Consequently, analysts are required to have a greater understanding of the long-term athlete development process. In the following section, we briefly detail how practice, and the structure of practice, fits into current conceptualizations of sports development and the attainment of high levels of skill. We evaluate research that has implications for the amount and types of practice which are considered important for athlete development across a longer time span.

**Practice amount is important**

There is considerable evidence showing that the greater the amount of time spent in ‘deliberate practice’ activities (i.e. highly relevant structured practice engaged in by performers for the primary purpose of improving performance), the greater the chance of success and achievement of expertise (Ericsson et al., 1993). By way of illustration, in Figure 1.1, we have presented accumulated practice hours from three different levels of competitive swimmers in Canada (International level, Junior National level or University-Varsity/Club level, adapted from data published in Hodges et al., 2004). Although all athletes had accumulated a significant amount of time practising swimming (over 5,000 hours), there were two notable findings. International
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Athletes had accumulated almost twice the amount of practice as their less elite peers (University), despite being approximately the same age. These amounts were close to 10,000 hours of practice, an amount suggested as a rough estimate of the number of hours of specialized, highly relevant practice necessary to achieve expertise (Ericsson et al., 1993; see also Simon and Chase, 1973). Second, although the Junior National swimmers were on average 4–5 years younger than the other athletes, they had already accumulated the same amount of practice as the University swimmers. These data and data from many other sports support this relationship between the need for high amounts of practice within a sport and success (for reviews, see Hodges and Baker, 2010; Ward et al., 2004). Consistently, successful athletes can be differentiated from their less successful peers, at relatively young ages, in terms of the accumulated practice in their chosen sport. Therefore, there appears a need to engage in significant amounts of practice early to accrue the requisite practice needed for success. This has been termed the early specialization pathway, typified by early involvement in a single sport (~5 or 6 years), coupled with high amounts of focused, high-intensity practice (Baker et al., 2009).

**Figure 1.1** Average accumulated hours in practice (and SE bars) for three skill/age groups of swimmers. INT = International senior competitors. JrNAT = National and International competitors at the junior level – U16 yr. Varsity/Club = University ‘senior’ swimmers

**Athlete-centred practice is important**

There has been recent debate about the type of practice activities that aspiring athletes should partake of early in their careers. Rather than encouraging the acquisition of high amounts of structured, or coach-led practice, researchers have proposed that there are benefits to be gained by high amounts of ‘deliberate play’ (unstructured) activities, early exposure to a large variety of sports and low amounts of coach-led practice. In Table 1.2, we have provided a schematic of these different types of practice with play and highly structured coach-led activities as opposite anchors of a continuum of such activities. The purpose of this table is to highlight the fact that athlete-centred, coach-directed practice is a middle-ground approach to structuring practice.
Deliberate play and unstructured practice

The term ‘deliberate play’ (Côté, 1999) is used to distinguish it from childhood play. It involves early developmental activities that are highly enjoyable versions of unstructured games, such as street soccer (Côté et al., 2007). According to Côté et al. (2007: 186), deliberate play affords participants ‘. . . freedom to experiment with different movements and tactics and the opportunity to innovate, improvise and respond strategically. It also allows children to perfect skills that would not be practiced in organized situations.’ This statement is often contextualized as opposite to what happens during deliberate practice. However, we argue that deliberate practice is not the antithesis of deliberate play, but rather the best type of practice is that which is athlete-centred, allows freedom in selection and promotes thought, active involvement and variability in how practice is structured. Neither play nor practice necessarily promotes these activities.

There is some evidence that deliberate play-type practice activities (i.e. low-structured game playing in basketball) resulted in better tactical game intelligence in comparison to more traditional structured practice (Greco et al., 2010). However, significant issues with the design and terminology in this study make generalizations difficult. Evidence also exists suggesting that play-type activities (i.e. unstructured, non-coach-led activities) within the primary sport are important for later success. For example, Ford et al. (2009) showed that early experiences in unstructured types of practice (before 13 years) were predictive of later success in soccer (i.e. being offered a professional contract). One argument for the encouragement of early play/unstructured types of practice is that it promotes intrinsic motivation, by virtue of the fact that play is engaged for fun and for its own intrinsic value (Côté et al., 2012; Soberlak and Côté, 2003). However, there is little to no evidence to support this suggestion. This issue of motivation and engagement is obviously a critical variable to consider if one wishes to recommend a particular practice pathway and promote commitment to practice.

Early sampling and diversified sports experience

Based on analysis of practice profiles of elite performers, there is some evidence that early diversification in many sports can positively impact later success in sport (Abernethy et al., 2005; Baker et al., 2003; Soberlak and Côté, 2003). However, the evidence is far from clear and a diverse sports background does not appear to describe practice profiles of elite soccer players or gymnasts (Ford et al., 2007, 2009; Law et al., 2007).

Benefits of early sampling of different sports have been proposed to result in positive transfer of tactical and physical skills, development of creative-type skills and enhancement of long-term motivation. In a review of cross-training effects, Loy et al. (1995) concluded that transfer occurs primarily during the early stages of development, due to improvements in physical skill. With respect to transfer in technical skills, the motoric transfer between two tasks is thought to be
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small, unless the tasks share almost identical features (Schmidt and Young, 1987). Cross-training and early diversity could have potential benefits for injury prevention. There is evidence that repetitive-use injuries in children in the United States of America are increasing, especially in sports such as swimming, baseball and gymnastics (Brenner, 2007; Dalton, 1992; Law et al., 2007). The assumption is that a wide, diverse participation will offset some of these potential injuries, but that only holds if the athlete actually does less specialized training.

In a study of world-class Australian national team athletes, Baker et al. (2003) reported a negative correlation between early breadth of exposure to other related sports (i.e. team ball sports) and the amount of sport-specific training required to obtain expert-level proficiency. This finding suggests that specialized practice could be offset by early (tactically related) sport diversity. The authors speculated that the transfer was cognitive (i.e. better decision skills) and physical (i.e. fitness related). There is some evidence supporting the transfer of tactical knowledge across sports (e.g. Abernethy et al., 2005; Berry et al., 2008; Smeeton et al., 2004), although a specialist advantage is still noted. Similarly, in studies of ‘creativity’, described as varying, rare and flexible decision making in complex game situations (Memmert and Roth, 2007), transfer of tactical creativity between handball, soccer and field hockey was noted. However, the largest improvement in tactical creativity was generally in the primary sport that had been physically practised. Consequently, while transfer from other domains could potentially play a role in skill development, there is neither strong nor sufficient evidence supporting diversity at the expense of specific practice for sport-specific improvements.

In summary, there are two proposed practice pathways to the development of expert performance in sport. These pathways are primarily differentiated in terms of their early emphasis (or not) on structured (coach-led/adult-organized) deliberate practice type activities in one sport, so termed ‘specialization’. In our view, the important distinction to be made with respect to practice and models of athlete development is not whether practice is coach-led or not, or specialized versus diversified, but whether the practice is structured to promote athlete-centred learning. This is likely to involve a mixture of play-type activities, self-directed practice and coach-led practice that is based on motor learning principles discussed in the first part of this chapter (i.e. variability, choice and cognitive effort; see also Tables 1.1 and 1.2).

Concluding remarks

We have reviewed two lines of research which suggest guiding principles for practice and motor skill development and the delivery of information by practitioners and analysts. This research was discussed with respect to short- and long-term engagement and the development of skills that aid technical and tactical proficiencies. As originally suggested by Ericsson et al. (1993), the best type of practice is ‘deliberate’ practice that is effortful and designed to improve performance. There is overwhelming evidence that practice which puts the learner at the forefront of the learning process and which is designed to foster effort, particularly cognitive effort, leads to better learning outcomes. As a means of engaging athletes in the error detection and correction process, the coach and/or performance analyst must be aware of this evidence and consider how information is presented. We have integrated and summarized these practice methods and pathways with respect to a continuum of structured-type practice activities (see Table 1.2). Unstructured or low-structured activities include activities such as deliberate play and self-determined practice. Even though coach-led formal practice might be considered ‘structured’, it is possible for the coach to primarily play a guiding role in setting up effective practice that allows and encourages an athlete to learn and improve through self- and coach-guided methods of problem solving, thus being relatively low in structure. Only participation in highly structured practice
(as shown on the right of Table 1.2), at least early in development, would be expected to have negative consequences for long-term retention and engagement in sport.

According to the Developmental Model of Sports Participation (DMSP) for elite performance proposed by Côté et al. (Côté, 1999; Côté et al., 2007, 2012), there are two distinct pathways towards reaching an eventual expert level of performance. These pathways emerge through early and continued specialization or early sampling/diversification of different sports and high amounts of play followed by late specialization. The major difference between the two pathways is the time (age) when specialization in one sport should begin, associated expectations for engagement in ‘deliberate practice’ and predicted outcomes with respect to long-term participation and motivation. We argue that early specialized practice that is athlete-centred will promote long-term engagement and, arguably, better foster the acquisition and mastery of technical skills necessary to succeed in sport. Advantages of early specialization seem to show up in the data repeatedly, in as much as many hours of ‘good’ practice are necessary to compete at the highest levels, especially in sports where there is a large participation base. However, more rigorous research is required to test ideas about the relationships between early specialization and technical and tactical skills development and, perhaps more importantly, the development of intrinsic motivation.

In conclusion, as player development programmes begin to focus on increasingly younger athletes, performance analysts and coaches should be aware of the evidence showing that an early start age, coupled with high amounts of deliberate practice, most often describe people who have reached success in sport (e.g. Bloom, 1985; Starkes and Ericsson, 2003; Ward et al., 2004). Early specialization seems to be the norm rather than the exception in the attainment of elite levels of performance skill. Côté et al., however, advocated a skill pathway that de-emphasizes early specialization in a single sport with coach-led structured practice; the rationale for this approach based on concern for potential negative effects of early specialized practice, such as decreased motivation and burnout. We argue that the critical issue is not so much whether an athlete specializes early, or whether the practice is coach-led, but rather what the practice activities entail and whether they promote cognitive effort, engagement and athlete-centred learning. As a key part of the athlete-centred learning process, performance analysts should be acutely aware of the benefits of early specialization and endeavour to focus efforts towards promoting practice methods that show positive effects with respect to motor skill learning, transfer and engagement.

References


Getting on the right track


Getting on the right track


