Psychophysics in Functional Strength and Power Training: Review and Implementation Framework

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ABSTRACT

Functional training is considered to be training that attempts to mimic the specific physiological demands of real-life activities. Most approaches to functional training, though, omit important factors that contribute to physiological and neuromotor adaptations. Cognitive factors related to sports influence physiological performance, and subsequently, physiological and neuromotor adaptations. We present a rationale and a theoretical framework by which to create effective functional training methods that incorporate cognitive factors. This framework draws upon recent developments and strong empirical evidence in the areas of dynamic systems theory, perceptual skills training, and motor learning/control. Emphasized within rigorous physical training are practice-related techniques and motor-learning strategies. In particular, mental effort, attention, and intention manipulated in a discovery-learning paradigm provide a framework for functional strength and power training. This framework is suggested to help maximize sport-specific physiological adaptations, and subsequently, sports performance.

Key Words: discovery learning, athletics, performance, practice, cognition, perception


Introduction

One of the fastest growing areas of physical conditioning and rehabilitation is functional training. Books and articles (e.g., 29) have popularized the term “functional” as a descriptor to training, exercise, and rehabilitation. Essentially, functional training is aimed at bringing the situational needs and constraints of real-life activities, including sporting events, into the training environment to enhance training effectiveness. Gambetta and Clark (29) refined this description for strength and power training by describing functional training as training in which exercises and movements are integrated, multidirectional, and proprioceptively enriched, and that the functional training process, “…insures optimal neuromuscular control and efficiency of function’’ (p. 26). In practical terms, functional training involves a host of agility drills, closed-chain exercises, ballistic movements such as medicine ball throwing, and balance activities that target physiological systems, neuromuscular systems, and to a lesser extent, motor abilities.

Evidence from a variety of sources suggests that improvements can be made to this approach. Recent works in applied dynamic systems theory (33, 87), cognitive and perceptual motor skill assessment and training in athletes (1, 34, 43, 88), motor skill training (52, 72, 84, 85, 91), and determinants of expert performance (25, 74, 81) provide groundwork that training can be more effective if put within an appropriate cognitive environment. Functional training should indeed be proprioceptively enriched, but without an appropriate cognitive or perceptual environment the interpretation and subsequent use of sensory signals (including proprioception) is incomplete. Unfortunately, the cognitive demands of sport are underappreciated and misunderstood outside the research environment (34) and, therefore, have not been systematically addressed as factors in the functional training environment. We maintain that by adding sport related cognitive and perceptual challenges, the physiological training adaptations are more sport-specific and offer the potential to be more transferable to sport performances. The purpose of this paper is to review this cognition-physical performance link and provide practical strategies for putting cognitive challenges into a functional strength- and power-training program. Specifically, we discuss how practice-related strategies and the concepts of mental effort, intention, and attention can be used in functional training. As a way of introducing these ideas, we provide a brief discussion of the role of cognition in sport and how it influences functional strength and power.

Cognitive Abilities in Sports

Many athletic events require forceful and explosive movements, making strength and power training a popular modality to improve performance. This type
of training improves some components of athletic events, like running speed and jumping height (61, 89). It is not clear, though, to what extent strength and power training improves overall athletic success, for there is only limited evidence to show improvement in actual sport skills with strength training (e.g., 48). When assessed across a group of athletes ranging widely in talent, strength and power may correlate to performance (4, 57, 66), suggesting that a base level of strength or power is necessary to attain a certain performance level (37, 70). Yet within a group of athletes at a similar talent level, especially high-level athletes, strength and power do not discriminate the more successful athletes or provide more than just a modest level of prediction for sport performance (for discussion, see reference 3).

This lack of association between strength or power and successful performance in high-level athletes is partly because strength and power tests, although generally similar to the methods used to train for strength and power, are often not specific to the conditions and movement patterns seen in the sporting environment (3, 8, 59). The purpose of functional training is to bring these conditions to the training setting, but the cognitive demands of sport are often neglected as part of this setting. Successful performance in sport requires a host of physiological and cognitive skills and abilities that are dependent or linked to one another (34, 81). For instance, Helsen and Starkes (34) concluded from a series of investigations on soccer players that the smooth and efficient movements of advanced players were made possible because of the better perceptual skills and faster and more appropriate decision making of the advanced players. This interdependence of motor factors and psychological factors necessary for sport skill execution characterizes these skills as being psychophysical in nature.

Much of what is known about the cognitive abilities and knowledge structure necessary for successful sports performance comes from data comparing experts vs. nonexperts. Experts have more elaborate domain-specific knowledge, such as knowledge of tactics and strategies. Experts make faster and better decisions, attend to and interpret information from the environment better, and are able to anticipate and predict outcomes better on the basis of situational information (1, 2, 28, 34, 56, 81). Many of these abilities contribute to perception-action coupling, a process whereby memories and knowledge contribute to interpreting and understanding sensory information, which in turn influences decision making and planning for motor actions. Even in “low strategy” sports and “automatic” movements, cognitive abilities are necessary to formulate and execute motor actions, and movements requiring a great deal of strength or power are no exception.

For example, agility drills are often performed to enhance rapid cutting movements, but aspects of the training environment typically do not match the competitive environment. In a training setting, attention may be placed on environmental factors such as the running surface and stationary obstacles, but is often on one’s own running rhythm or speed. This may differ markedly from the real-life situation such as a football running back cutting and evading tacklers on a muddy field. Similar to training, when and how a cut needs to be made are dependent on the athlete’s split second assessment of the environment (e.g., How solid is the footing? How much time until contact with the object/opponent?). But decision making in the competitive environment also requires knowledge of the opponents’ characteristics (e.g., What are the tendencies and skills of the opponents?), game circumstances (How much time remains? Is a first down necessary?), and a host of other procedural (how to do) and declarative (what to do) knowledge structures. In contrast to training, attention is rarely placed on oneself during competitive action. It is not our goal here to discuss these cognitive factors but, rather, to stress that forceful and powerful movements in athletics do not occur in a cognitive vacuum. In real-life settings, strength and power movements are often performed in situations of varying cognitive and perceptual challenges and thus should functional training.

Influence of the Cognitive Environment on Performance and Physiological Adaptations

Evidence From Training Studies Using Practice-Related Techniques

By convention, practice differs from training in that practice addresses psychological and motor skill learning, whereas training focuses on improving physiological capabilities such as metabolism and muscle size. Practice encompasses a variety of methods ranging from mental imagery to rote repetition of movements. Although practice can be physically rigorous, the emphasis is on improving movement techniques, strategies, and the mental skills necessary for peak performance (e.g., learning concentration and overcoming anxiety). In comparison, training to alter physiological capabilities often neglects these skills and strategies. We emphasize that functional training is not a substitute for either practice or physiological systems training but, rather, that functional training should be thought of as a method to combine elements of each to increase training specificity to enhance physiological adaptations and promote transfer of abilities to the sport setting. As described below, resistance-training programs that have added practice-related techniques have demonstrated the efficacy of such methods.

Elegant examples of such a combination can be found in the work of Hewett and colleagues (35, 36). Specifically, Hewett et al. (36) reported improved jump
height and power after a specialized plyometric training program in teenage women volleyball players. The plyometric training emphasized practice of jumping techniques and used various motor-learning techniques such as verbal and visual cueing. These improvements were better than those seen after a generalized training program, and the authors also found changes in neural coordination that they suggested might help prevent injuries. Using the same training protocol for only 6 weeks, Hewett et al. (35) found a substantial reduction in injuries in women athletes during the course of their soccer, basketball, or volleyball seasons. Other training studies (20, 86) as well as computer simulations (15) have concluded that strength training to improve specific sport skills (e.g., running, jumping, punching) may only be effective when combined with specific practice.

Additional evidence can be found in studies that have used practice-related techniques within the strength or power-training program. For instance, coaching instruction and feedback improves the quality of explosive force application in sprint starting and consequently, the quality of the start (55). Others have shown that mental practice alone (93) and the distribution of practice scheduling (78) can influence strength development. These data suggest that training to improve specific muscular strength or power measures should incorporate methods that are traditionally associated with practice to maximize improvement and, potentially, the transfer of training adaptations to sport performance.

**Why Practice Improves Strength and Power**

Many factors contribute to strength and power (for reviews see references 3, 47), but it is increasingly clear that the production of fast, forceful, and purposeful movements are largely outcomes of a precisely controlled neuromuscular system and are modifiable through learning (12, 20, 24, 68). For example, Hutchinson et al. (38) suggested that their unique training method of Pilates exercises (a mind-body exercise regimen with an emphasis on kinesthetic awareness) and water training allowed rhythmic gymnasts to optimize their leaping ability. These results prompted the authors to conclude “that leap training is more likely a cognitive, learned effect rather than a purely motor strengthening effect” (p. 1546). Strength and power, particularly if applied in a specific manner in a functional setting, are characterized by coordination and skill and as such should be practiced as any other motor skill.

**Effort, Attention, and Intention as Cognitive Factors Influencing Muscle Function**

When done properly, practice enables one to search for solutions to movement problems and find answers to these problems that are specific to individual needs and abilities (33). During problem solving, one’s mental state dynamically interacts with environmental and task constraints in an ongoing process to optimize the movement within these constraints. Specifically, an individual’s mental state regulates movement creation and coordination and, thus, the neural and physiological adaptations that arise from these movements (43). Noticeable examples are that mood state can alter gait patterns (76), and persons with Type A personalities exhibit more muscle coactivation during movement tasks (31).

Posture and balance control is a common target of sports functional training and is strongly influenced by the cognitive and behavioral environment, such as whether postural changes are self-paced or reactive (11, 27, 65). Similarly, preprogrammed reactions—compensatory muscle synergy patterns rapidly activated to maintain coordinated movement patterns when movements are disrupted—are formulated, or learned, in advance to counter “conceivable” disruptions (49). Learning preprogrammed reactions and the specific nature of these reactions are dependent on many factors, including environmental and instructional context, specific task demands, and the type of sensory stimuli that trigger the reactions (40, 49). In athletics, what this means is that quick and effective responses to movement disruptions cannot be ascribed to “innate” reflexes or a strong muscular system but, rather, to learned coordination and specific physiological and neuromotor adaptations.

How then, should the cognitive environment be structured in order to produce the most effective physiological and neuromotor adaptations for sport? We believe the evidence most strongly shows that 3 interrelated factors markedly affect functional strength and power training: (a) directed mental effort, (b) attention, and (c) intention (see Ericsson et al. [25] for a discussion of these factors in deliberate practice). There are other practice-related factors that have implications for strength and power training, but effort, attention, and intention have the most relevance in a sport-based context and have direct physiological consequences. Moreover, of all the constraints to movement, Kelso (44) has described cognitive factors such as intention as the most influential.

**Effort, Attention, and Intention Stimulate Specific Psychophysical Adaptations**

Strong physiological effort is a prerequisite for gaining strength and power. High intensities produce the necessary mechanical stresses that generate musculoskeletal adaptations, and high intensities maximize motor unit activation (e.g., firing rates and recruitment of high threshold motor units). But gaining specific muscular adaptations requires controlling the nature of physiological effort. Slow, sustained efforts lead to different neuromuscular activation patterns when com-
pared with rapid efforts, and submaximal contractions result in different patterns of motor unit activation and firing rates than do maximal contractions (94). Even small variations in intensity can change the nature of motor tasks and can result in markedly different muscle activation patterns (58). Controlling this physiological effort, including producing maximal effort, requires directed mental effort (53).

‘Psyching up’ before a maximal effort lift is one example of mental effort being directed to produce a particular physiological state. As demonstrated by electroencephalography, other levels and types of mental effort correspond to movements performed with different strategies (71), movements varying in their meaningfulness to the individual (18), and movements varying only slightly in force or speed (30, 62). Accordingly, Jeannerod and his colleagues (19, 41) have shown that mentally imaging particular levels of physiological effort has direct physiological implications. These findings imply that to receive a desired physiological response mental effort must be directed toward that response.

Mental effort is clearly as important as physiological effort, but where in a functional strength- and power-training program should the mental effort be directed? Attention and intention have considerable influence over physiological adaptations and skill development, and therefore should serve as a starting point in addressing this question. Attention control elements important to athletics include focus, selective attention, attention switching (or shifting), and alertness. Focusing on relevant cues that provide critical strategic information is a particularly important mental skill seen in accomplished athletes (73). Attention control also helps in anticipation; anticipation is one of the most important factors in making fast and appropriate responses, and improving the quality of movement (81). For example, muscle activation patterns for very rapid arm movements are set before movement according to what a person anticipates will happen during and after the movement (39). On a larger scale, muscle coordination in vertical jumping is dependent on the anticipated final equilibrium position, which is dependent on what movements follow the jump (51). These findings are consistent with many studies that have shown that trunk and leg muscle activity to ready the body for movement (anticipatory postural control) and to maintain balance after disruption, are highly influenced by the individual’s anticipation and perception of task demands, strategies to accomplish the task, attention demands, and other behavioral and cognitive factors (7, 21, 23, 27).

Attention control is clearly important, but how can this be reconciled with observations that highly skilled athletes perform activities automatically without deliberately thinking about them (73), and how is this important to functional training? First, one goal of functional training is to practice movements in order to make them automatic. Second, even though accomplished athletes may have little idea of what they focus on during skill execution, at some conscious or subconscious level they are focusing on relevant cues. For this reason, Singer et al. (75) advocated that skilled motor performance can be best achieved if learners adopt a nonawareness type strategy (later modified as the 5-step approach). Nonawareness refers to a lack of attention placed on the activity while it is in progress, but learners are instructed to preplan the movement (e.g., using imagery) and focus on a specific situational cue. Singer and colleagues (52, 75) and later Wulf et al. (91, 92) have demonstrated convincingly that the locus of attention has a powerful influence over the learning and performance of motor skills. These authors have shown that focusing on one’s body or bodily movements (internal focus) results in poorer learning and performance than focusing on external cues, such as sports equipment (e.g., golf club) or the movement effect (e.g., ball trajectory). External focus also helps in learning of fundamental body control skills like whole body balance (72). Interestingly, Wulf et al. (92) also noted that sport-teaching materials often counter these findings by instructing students to pay attention to themselves and not the equipment or movement effect.

Awareness strategies also influence strength production, as demonstrated by subjects with muscle soreness who exhibit more strength when adopting an associative strategy to focus on and be motivated by the pain (63). The implication of these data for functional training is that what one attends to influences the quality of the movement and learning. Specifically, we do not advocate athletes focusing on themselves (as is the case, for example, when looking into a mirror) but, rather, direct attention and mental effort toward strategies and cues relevant to specific sports performance. Determining relevant cues, preplanning strategies, and anticipation all require specific intentions.

Intent is a psychological process that determines one’s outcome goals and achievement goals (i.e., strategies) for movement. Goals are well recognized to help improve performance (42), and actions are planned and controlled based on the intended effects (64, 72). Without knowing why one is engaging in movement or what one is trying to accomplish, the desired result is difficult to achieve. Specific goals and strategies include those that address how to accomplish a training program or a particular exercise. At first glance, it might seem that such intents dictate the use of specific biomechanical techniques, but this is not necessarily so. The same exercise or movement done with different intentions (e.g., speed vs. force; speed vs. accuracy) or efforts can lead to markedly different neuromuscular control signals and movement forms (32, 82, 83). This
is particularly evident in dance, where a dancer’s emotional intent leads to subtle differences in biomechanical features (79) that give the dance meaning and aesthetic appeal (26). Latash and Jaric (50) concluded from their study, in which subjects were given different instructions to accomplish the exact same mechanical task, that “…patterns of muscle activation, including those of preprogrammed responses, may reflect features of both the explicit motor tasks and the subject’s intention that may have no obvious mechanical correlate” (p. 198). An individual’s intent is so influential to physiological output that even apparently similar strategies designed to elicit maximal effort (“do your best” vs. “beat your best time”) can have a marked difference on maximal effort performance (80). It is thus apparent that physiological adaptations resulting from a training program are not only influenced by the movements performed but also the cognitive state in which the movements are performed.

Specific intent and effort lead to specific, and measurable, physiological changes. Behm and Sale (10) exercised subjects 3 days per week over 16 weeks in an ankle dorsiflexion strength program. One ankle trained isokinetically at a fast speed and the other ankle trained isometrically. Under both conditions, the subjects tried, or intended, to do maximal fast ballistic movements. A ballistic movement poses a different psychomotor challenge than a maximal strength exertion, despite both contractions being maximal physiological efforts (94). According to the specificity of training principle, the strength gains should have been specific to the training velocity. However, the isometric-trained limb did not improve isometric strength but, rather, had the best improvement in strength at high speed. Coinciding with the power increases were faster muscle activation speed and faster muscle relaxation. These data imply that an important element in the specificity of training principle is the intent behind the muscle action and the nature of the effort given. As these authors concluded, a key training stimulus is the nature of the motor command and resultant motor unit activation patterns associated with high velocity movements. The intent of the muscle contraction gives rise to a particular motor command. These motor commands activate the muscles in a manner consistent with the intent and, further, promote physiological adaptations that are specific to the intent. The nature of mental effort directly influences the quality and quantity of movement, and therefore, any subsequent physiological adaptations.

Implementation Framework

The Discovery-Learning Paradigm

Given that effort, attention, and intent are important considerations in the training of functional strength and power, questions arise regarding what the precise nature of these cognitive factors should be and how they should be introduced to the athlete. We propose that a discovery-learning paradigm best enables the manipulation of these psychological processes to be sport specific. In brief, discovery learning (or exploratory learning, see references 33, 84) stresses that motor learning is most effective when learners solve for themselves how and what movements to make given the situational constraints imposed upon them. Empowering the learner to direct the learning environment, such as when using self-controlled feedback, produces more effective learning and is characteristic of the practice methods used by high level performers (74). Trainers and coaches, rather than giving explicit instructions about what to do, meet learning objectives by manipulating movement and performance constraints (see next section about constraints). In this manner, practice is the process of solving problems and not simply repeating solutions.

Applied in a sports training setting, Handford et al. (33) suggested that athletes best learn when they self-discover movement solutions through free exploration of movement and problem solving. Evidence for this approach in a strength and power environment can be found in Almåsbakk and Hoff’s (6) study on subjects performing high resistance, slow speed, bench press exercises vs. subjects performing low resistance, high speed, bench press exercises. Similar improvements were found in strength across the force-velocity curve in both groups. The authors attributed these results to the instructions given to the subjects to perform maximal speed contractions regardless of the weight and actual speed, and stated that the “subjects were able to explore and exploit the coordination dynamics implicit in the subject-environment interaction, thereby discovering a more optimal solution to the problem” (p. 2050). Further, these authors suggested that this exploration could lead to more efficient coordination and contraction patterns because the subjects were not simply training muscles but were purposeful in training for movement.

Even though athletes apparently learn on their own in discovery learning, the trainer’s role is important. According to Vereijken and Whiting (84), the instructor must “get inside the learning situation and discover what the principal obstacles are to progress” (p. 100). What this means is that instructors must know the general difficulties in learning a particular skill, what troubles individual athletes might have, and what skills are necessary for successful performance. It is also necessary for the intention of the athlete be known. For example, because intention drives visual processes (e.g., what cues to look for) the learning and performing of motor skills involving catching, deliberate contact with objects, and other ‘interceptive’ actions are highly dependent on the exact nature of the athlete’s intention (43). Strength coaches must provide
the environment for discovery learning to take place, which can include manipulating the physical space and giving instruction and counsel to guide the athlete to solve movement problems, rather than give explicit prescriptions. To illustrate for functional training, we suggest that athletes not be told to perform weight-training exercises with specific techniques. The athlete, within the bounds of safety, should be free to explore the exercises and become aware of their own movement effects and perceptual outcomes. Rigorously defining ‘proper’ form and the use of mechanical stabilization and anticheating aids excessively constrain athletes’ exploration and problem-solving movements, and bear little resemblance to that which occurs during athletic performances.

With no instruction, however, the athlete may search endlessly for a proper movement solution (33). Athletes may learn poor movements and adopt bad habits. The coach or trainer can guide the athlete by providing purposeful intent, ideas about where to focus attention, and clues to key perceptual cues (54, 88). In this fashion, athletes are able to resolve problems and begin to understand the nature of movement on their own, and determine optimal solutions for themselves.

Because the athlete is continually searching for solutions, variability in performance is expected. Intuitively, movement variability is undesirable, yet variability reflects a continual optimization process in the face of ongoing changes in the environment, the task, and the individual (33). Thus, even though movements may look the same, internal and external factors lead to movements being executed in different ways (13, 69). Singer and Janelle (74) noted that when athletes are free to generate their own movement solutions during practice they learn more adaptability when faced with novel performance situations, which may be particularly important for higher-level performers (85). As such, functional training within an appropriate psychophysical environment provides a setting to exploit movement variability as a mechanism to enhance an athlete’s adaptability, creativity, and spontaneity—all of which can be argued to be hallmarks of the best performances in sport.

**Strategies for Implementation**

The many factors that influence movement performance fall under the general categories of organismic, environmental, and task constraints (33, 60; see Figure 1). Though it is out of the scope of this paper to discuss these constraints in detail, it is necessary that coaches and trainers be aware of them to provide direction and intent for the athlete. Organismic constraints refer to the individual’s own make-up; their physiological and psychological capabilities and momentary state, such as intent. Environmental constraints include the physical (e.g., weather, type of support surface) and sociocultural influences (e.g., potential stressors, expectations) to movement. Task constraints are restrictions placed on movement as dictated by the task itself, such as rules and use of equipment. Figure 1 depicts how constraints influence an individual’s planning and decision making, and ultimately, the nature of the motor response. To mimic the constraints seen and experienced in athletic performance to the training environment, it is advisable that these constraints be thought of in advance and then presented during functional training. In this manner, the coach or trainer can provide constraints or scenarios that directly influence performance behavior during training, and enhance overall training effectiveness.

To illustrate, consider the use of plyometrics and box jumping to improve rebounding performance. If the intent of jumps is simply to get to the top of the next box, then the neuromuscular coordination patterns and psychophysical skills that ready a basketball player for rebounding are little trained. Instead, rebounding should be the intent and jumping becomes a means to a goal rather than the goal. Recognizing the constraints and problem-solving skills in rebound-
Table 1. Procedures for designing and implementing a functional training program to improve jumping for spiking in volleyball.

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<th>Step</th>
<th>Data and concepts</th>
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<tr>
<td>1. Physiological, perceptual motor, and mental factors and skills necessary for successful performance.</td>
<td>Jump height is important and height during spiking has a large technical component (77). Control of limbs is critical for skilled and safe jumping (22). Ball provides advance information to improve response speed (5). Players pick up advance information from setter's motions before setter contacting ball (90). Defensive players scan and recognize offensive attack patterns to prepare defensive response (16). Optical flow field constrains temporal movement patterning during spiking. Large between trial variability in which variation in 1 variable immediately induces variation in other variables. Motions not preprogrammed or stereotyped, but based largely on perceptual coupling regulating continuous and prospective actions (69).</td>
<td>Jumps in “tight sets” may cause poor motions and predispose to injury—teaching specific jump strategies may help reduce injury (9). Dufek and Zhang (22) data is based on defensive block jumping—it may not directly apply to spiking. Wright et al. (90) data is based on defensive players reacting to offensive hits—may not directly apply to offensive players. It is reasonable to suggest that offensive players do the same. Sardinha and Bootsma (69) data imply that simple repetitive jumps will not train the system for the adaptability and ongoing control required of actual spiking. All together, these data suggest that jumping should be coupled with ball action, constrained surroundings, and variable jump tasks.</td>
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<td>2. Determine the specific constraints that influence movement and performance outcomes and the obstacles that need to be overcome for learning to take place.</td>
<td>Players are constrained by the net and set placement. Players respond to blockers and defensive sets. Body motion is coupled with ball timing (17).</td>
<td>Data from basketball supports the idea that jump form differs when defenders are present (67). Davids et al. (17) data from volleyball serving, but reinforces information presented above that ball flight influences motor actions.</td>
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<td>3. Create a training environment that addresses strength or power as well as the psychomotor and mental factors necessary for performance. Address attention and intention.</td>
<td>Intent: Successful spikes. Attention: Placed on ball and setter. Constraints: Close to net to constrain jumping area and provide a boundary; include ball set to force ball timing. Power development task: Box jumps/plyometric drills at the net with ball set into the air. Ball height varied as in actual games but, generally, should force maximal height jumps.</td>
<td>Provided here is a simple example that can serve as a starting point. Though defensive movement may influence the hitter's actions, including entire defenses would not be practical. Adding blockers may provide important environmental constraints as training progresses.</td>
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<td>4. Carefully present constraints, obstacles, and cues in a fashion that allows the athlete to discover on their own the best way to accomplish goals.</td>
<td>Vary set height often to force adaptation to tight sets and other game variations. Closeness of jumping platform to net can be varied to mimic different jump constraints.</td>
<td>Technical skills for injury prevention (e.g., 9) can be weaved into these modifications.</td>
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Plyometric training can address these skills by simulating real-game chaos.
Unstable surfaces, throwing balls into the air to be caught, and having “defenders” present to impede jumping are just a few constraints a creative coach or trainer can devise to challenge the athlete’s cognitive and physical skills necessary for successful rebounding performance. Table 1 provides an example for volleyball training and describes the steps to create an appropriate training program on the basis of constraints and skill-related perceptual factors.

It is important here to reiterate 2 points. First, the functional training method described is designed to enhance the specificity of physiological adaptations, not enhance perceptual and cognitive skills. Second, it is recognized that not all physiological systems training should be done as functional training. For example, hypertrophy training requires a protocol different from the one used to train the neural coordination system (14, 46). Hypertrophy training may constrain movement exploration, yet may promote certain muscle adaptations, like increasing muscle size, that are building blocks to functional performance.

**Practical Applications**

The framework of discovery learning used in a functional training setting requires that coaches and trainers be able to understand the learning situation. This means the needs and constraints of successful sport-specific performances must be identified, as must the athlete’s individual psychological and physiological strengths and weaknesses. Coaches and strength coaches must work together to devise the functional training to overcome individual weaknesses while at the same time enable athletes to take advantage of their particular strengths. Within the training program, athletes must be allowed to problem-solve on their own and learn how to accomplish goals and overcome obstacles. The following steps provide a guideline by which to begin designing functional training programs that incorporate cognitive and perceptual factors.

1. Determine the physiological, perceptual, and psychomotor factors and skills necessary for successful performance.
2. Determine the specific constraints that influence movement and performance outcomes and the obstacles that need to be overcome for learning to take place. Define these obstacles and constraints as problems to be solved. This list should be specific to individual athletes based on their unique abilities, strengths, and weaknesses.
3. Create a training environment that addresses strength or power as well as the psychomotor and mental factors necessary for performance. As a starting point, address mental effort, attention, and intention to determine the mental factors necessary for training. Training need not address all of these factors at once and can progress from simple to more complex.
4. Carefully present constraints, obstacles, and cues in a fashion that allows the athlete to discover on their own the best way to accomplish goals. Monitor progress and present new constraints and obstacles when learning plateaus.

Table 1 demonstrates the use of these 4 steps in designing a functional training program for volleyball. For this example, data were gathered from the literature regarding the factors, skills, and constraints (i.e., steps 1 and 2) important for volleyball spiking. Unfortunately, this information is not readily available for many sports or sport-related tasks. In such cases, coaches should be consulted to provide as much information as possible. It may be necessary to examine data from similar sports and sports skills, but application of these data must be done carefully and knowledgeably.

These guidelines focus on the functional training goal of bringing the situational needs and constraints of real-life activities into the training environment to enhance training effectiveness. This environment includes many psychophysical elements that are specific to individual sports. Altering movement intent and attention elements is a starting point for manipulating the cognitive environment necessary for enhancing the opportunity for sport-specific physiological adaptations to take place.

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