SPORT TRAINING SPECIFICITY vs. THE PRINCIPLE OF DYNAMIC CORRESPONDENCE

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The exercises an athlete does during practice are supposed to effectively and efficiently improve their performance in their sport. For that to happen, the activity needs to be appropriate, or specific, for that sport or event. The basis of this training principle is that the body adapts to the specifics of the training. The form and extent of this adaptation depends in part on the athletes genetics and in part on the training (1). Some individuals adapt in the direction of, for example, marathon running while other individuals, gymnastics. A runner cannot be a world class sprinter and long-distance runner at the same time, even if both are running. Very different innate abilities and adaptations to training are involved. Marathon running involves relatively small forces exchanged during repeated, stereotyped movement, for a long time, without rest. Gymnastics involves extremely high forces exchanged while making complex, often very quick movements, in up to six different events, placing great demands on an athletes ability to coordinate their body (2).

But if training is supposed to be specific, why do swimmers and skiers sometimes train on dry land; no water or snow? Why do track-and-field sprinters lift weights? Many Olympic weightlifters also participate in CrossFit. For that matter, why do gymnasts push panel mats back and forth across the floor? Most Olympic athletes do a lot of exercises that have no obvious similarity to their competition skills.

If the most specific training for a swimmer is swimming, why has it been clearly demonstrated, over many years, by many coaches and athletes, that swimmers get better faster if they also lift weights? (3) If the most specific form of training for a gymnast is gymnastics, why has experience shown the value of dedicated strength and conditioning conditioning exercises; for women, their fifth event? Clearly, comparing the concept of sport training specificity with what has actually been proven to work best in practice shows that there are some serious contradictions with this concept of specificity as the only driver of positive adaptation and improved sport competency.

The Principle of Dynamic Correspondence

The Principle of Dynamic Correspondence was developed by Soviet sport scientists and can be more useful for choosing exercises (4). This principle states that the activity performed in training, to improve performance in competition, must have a similar, or corresponding, exchange of forces. The forces in the training exercise should correspond to the forces in the skill performed in competition. Of course, this means that the force exchanges in the sport are well understood (5). If mean or peak forces are low, then strength training is not all that necessary. But if mean or peak forces are high, then the athlete must be very strong. If mean or peak forces are relatively high, sub-maximal but are repeated often, then athlete and coach are facing a strength-endurance demand. The Principle of Dynamic Correspondence directs your

attention towards the forces involved in the sport or event. The key word is dynamic in the sense of the mechanics developed by Isaac Newton. In Newton's mechanics, kinematics refers to the motion of bodies without considering causes, and dynamics is about the relationship between the motion of bodies and the forces that cause these motions. Newton's mechanics have proven their value for over 400 years, for everything from biomechanics to moon landings.

For example, the forces causing the stride of a marathon runner are relatively low (6). Therefore, one should not be surprised that marathon runners do very little strength training (5). In contrast, the impact forces of many gymnastics skills are exceptionally high. Maximum forces on the hands during the uneven bars back giant have been reported as ranging from 3.1 to 3.6 times body weight. At the elbow and shoulder, average joint reaction forces ranged from 0.7 to 1.8 body weight (7). 13 to 16 times body weight have been measured during landings on competition mats (8). At the Achilles tendon during a backwards flipping takeoff, forces of 10,000 Newtons have been recorded; sixteen times the gymnasts body weight (9). Consequently, gymnasts, female and male, are typically very strong and powerful.

To return to the previous example of the track-and-field sprinter: if the goal is to improve a 50 second 440 yards to a 45 second, a trivial calculation reveals that the mean force of each step propelling the sprinter around the track in that faster time would have to be significantly greater. This calculation of mean forces involved in sprinting a 45 second 440 would lead coach and athlete to more strength training to accomplish their goal. Both the need for weight lifting, due to the higher forces, and increased explosive strength become immediately apparent from that calculation. Alternatively, "specific" exercises that mimic a 45 second 440 would be full of uncertainty. It might be possible to gain that strength by simply sprinting more or sprinting differently, however accumulated experience and data has shown that weight training is a much more effective and efficient method of improving maximal and explosive strength than more running. After this strength is developed, it is then applied to sprinting by learning to use the newly developed strength and power in a technically efficient manner.

What does the Principle of Dynamic Correspondence mean for gymnastics?

Gymnastics coaches should consider the Principle of Dynamic Correspondence before assigning exercises and drills, rather than ill-defined notions of specificity. The forces of many advanced gymnastics skills are very high. Even a simple handstand, the symbol of gymnastics, involves supporting the entire body weight on the arms. Most people would struggle to hold a barbell of over 100 lbs. above their head for any length of time, but that is essentially what a gymnast does in a handstand. Handstand walking or handstand pirouettes demand supporting the entire body weight on just one arm, however briefly. And as soon as there is movement, accelerations can further increase the forces being exchanged.

Moreover, not only the size of the force is important, but the time course of the force exchange should correspond (5). The force-time process should be that which is common in the sport; in gymnastics this is an explosive stretch-shorten contraction. For example, there are few constant speed (isokinetic) movements in gymnastics as there are in swimming. The joint angle should

be that angle that is correct in the sport or skill. Most of gymnastics technique training or skill practice necessarily involves very fast stretch-shorten, or plyometric movements. Therefore even more plyometrics as conditioning is probably not necessary and could even cause overuse injury because these involve repeated, heavy impacts (10). Moreover, a gymnast's technical execution of a skill is highly related to his or her physical abilities, in particular strength and flexibility. Repetition alone will eventually improve strength and flexibility, but this method takes a long time and many repetitions, with an unacceptable risk of overuse injury. Many technical execution errors are related to a lack of strength or flexibility. The gymnast compensates for his or her lack of strength or flexibility with a variation of correct skill execution that is usually worse than ideal. A more rational method would be to develop the requisite strength or flexibility with effective, efficient exercises, for example weight lifting, and then do the technical skill practice. This is an important, but frequently ignored, aspect of correct periodization (2).

Gymnasts and coaches are always trying to get faster and stronger so that they can perform more difficult skills. But the foundation of speed and power is maximal strength: the mathematical correlation between an athlete's maximal strength ability and hers or his speed and power is very high, and increases as the load increases (11). An athlete's maximal strength is the most force she or he can exert. In a Level 5 floor exercise back tuck, the gymnast's maximal strength and explosive power are closely related. But in the punch-take off to a double twisting, double layout, the gymnasts maximal strength and explosive power become essentially the same ability because the forces exchanged during the take off are so much greater (12,13). This fact should be taken into account when preparing the Level 5 gymnast as well as the double twisting, double layout gymnast.

Finding exercises that safely, efficiently, and effectively develop maximal and explosive strength for a beginning gymnast, for example a level 2 or 3, is not too much of a problem. Push ups and drop jumps, for example, will suffice. Having compulsory level girls practice rings skills, drills, and routines can develop upper body maximal strength. For an advanced gymnast however, this is a great training methodological problem because they are already very strong. There is a great deal of practice that this problem is most effectively and efficiently solved with special strength exercises, in particular weight lifting (14). Weight machines are safer, require less learning, and potentially more efficient than free weights (15). However, free weights like barbells have the advantage of requiring the stabilization of supporting muscles at the same time as well as posing a coordination demand that machines do not. The bilateral strength deficit is potentially an important issue in gymnastics. The bilateral strength deficit is the name of the fact that the sum of the maximal strength of each limb measured separately is always more than the force measured from both limbs at the same time (16,17). Free weight training works directly on the bilateral deficit. Both load the weaker arm or leg more than the stronger, helping re-establish strength balance in the body.

The common use of rubber bands in gyms should be viewed with scepticism because the forces do not correspond to those in gymnastics. In many fast movements, before any movement of the body can be seen, impulses to the muscles that stopthat movement can already be

observed. An exercise against an elastic band begins with very little resistance and ends with the most resistance, at the same time as the antagonist muscles would be active to end the movement (15). In other words, the coordination with a rubber band as resistance is exactly the opposite muscle activation pattern of a gymnastics movement. This is a potentially serious issue because coordination is so important in gymnastics. Elastic bands are certainly a safe, inexpensive way of making resistance, but their benefit is limited as well as their use. The dynamics of the vast majority of gymnastics movements is very different than the movement dynamics against elastic resistance.

Gymnastics coaches should be aware that if a gymnast's maximal strength increases, the stabilizing muscles for that movement must have their maximal strength also increased. Otherwise, force will be dissipated, jiggling the body core instead of propelling the gymnast off the apparatus. An unstable body core results not only in an inefficient use of force, in a sport with small margins, but also potentially dangerous for the body core. This specific concept is often called "stiffness" or "tightness" in gymnastics and is why true core strengthening exercises are an important component of a well designed, comprehensive strength training program.

Physical therapists are experts at returning athletes who have a reduced ability, for example due to an injury, back to a normal, functioning level. However, gymnasts do not have normal, functional ability: gymnasts are way off the charts above normal in part due to the high forces involved in gymnastics skills. Therefore, a gymnast cleared by a physical therapist is still unprepared for gymnastics training because the forces in gymnastics are so large and physical therapy typically avoids heavy resistances. Once a gymnast is cleared for gymnastics by a physical therapist, there is still an important amount of maximal strength and flexibility training that has to be done before the gymnast can safely and effectively return to gymnastics practice and deal with the dynamics of gymnastics. Ignoring this situation has led to tragedy. Fortunately, there are many physical therapists who are either well trained in strength and conditioning or who will make a referral to a strength and conditioning coach. Establishing a comprehensive gymnastics sports performance team is essential to the safe and progressive development of high-performance gymnasts (18). This team can help with both the continued development of high levels of maximal strength that are essential to continue progressing safely in the sport as well as, in case of injury, help the gymnast successfully return to gymnastics.

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