Coaching Applications

Asymmetries in Swimming: Where Do They Come from?

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Abstract

This paper reviews the causes of asymmetries in swimming. A model of factors related to asymmetries was used as a basis for discussion. Asymmetries can include bilateral asymmetries and muscle imbalances leading to postural changes. The link between asymmetries and swimming performance is highlighted throughout.

Introduction

To perform at the highest level, swimmers must have both arms and both legs contributing optimally to maximize propulsion and to have body postures that minimize resistive drag. However, many swimmers fall short of their potential performance due to asymmetries in strength and/or flexibility. These physical asymmetries can mean that more work is delivered by arms and/or legs on one side of the body than the other. Asymmetries can also have a resultant effect upon technique and overall body posture increasing resistive drag.

In addition to bilateral asymmetries (left-right), antero-posterior (front-back), strength and flexibility imbalances and deficits can limit performance by reducing capacity to produce propulsive force, reducing the range of motion, or creating postures that do not minimize resistive drag. Strength and flexibility imbalances and deficits can also promote the development of injuries, for example, shoulder impingement syndrome, breaststroker's knee, and spinal problems.

Appropriate training and rehabilitation to correct deficits and imbalances in strength, flexibility and posture include physiotherapy techniques, strength and flexibility training programs, and technique corrections. However, great caution must be exercised when making decisions about whether a swimmer's training program or technique should be modified. Four main questions must be carefully considered:

1. What are the likely causes of the asymmetries?
2. How can asymmetries be identified and measured?
3. Do the observed asymmetries affect performance?
4. What training and rehabilitation can be administered to correct the asymmetries?

In this paper we address the first question as a means of providing the background knowledge to underpin sound decisions with respect to questions 2, 3, and 4. Figure 1 provides a model of factors associated with asymmetry in swimmers.

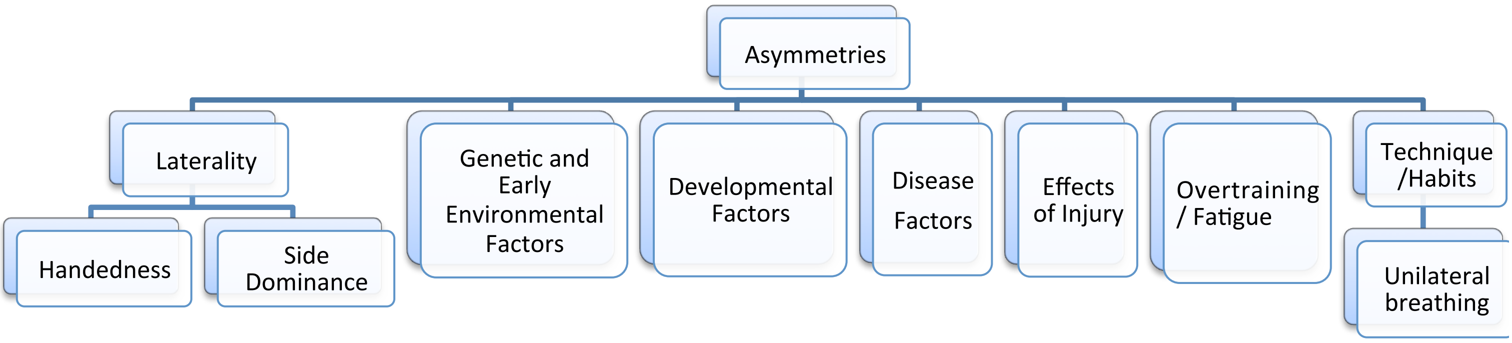

Figure 1: A Model of Factors Associated with Asymmetry in Swimmers

Laterality: Side Dominance and Handedness

Humans have a natural tendency to use one side of the body in preference to the other. This is termed 'lateralization'. The tendency to use one side in preference to another originates from both genetic sources and development after birth. These become evident early in development prior to the learning of unilaterally oriented activities and sports.

Having a preferred side can cause asymmetries both as a primary cause and as a secondary cause through strength and neural development resulting from favoured use of the dominant side. However, even without uneven use of sides in the sporting activity, asymmetries can exist. For example, although breaststroke does not encourage uneven development in terms of the demands of the activity, side dominance causes asymmetries in the leg kicks of most breaststroke swimmers. Given the natural tendency towards asymmetries in breaststroke swimming coaches are advised not to emphasise symmetry when developing technique in the breaststroke kick.

Other evidence of the influence of lateral preference on symmetry comes from activities and sports in which secondary developmental effects should be equivalent across sides, for example, in running and cycling where asymmetries are very common despite the symmetry of the activity itself.

Genetic and Early Environmental Factors

Variations from bilateral symmetry in traits that are normally symmetrical have been linked to environmental and genetic causes. One common outcome is the development of a 'positional preference' in the first few months of life in which the infant's head is turned preferentially to one side and development of active movement on the other side of the body is limited. This may be related to parental side preference. For example, a right handed parent can influence the newborn baby's head turning response.

A high growth rate can cause asymmetry in finger length, ear height, foot length and foot width. Thus, discrepancies in the size of the propelling surfaces in swimming may exist in some swimmers due to genetic and early environmental factors.

Structural asymmetries can emerge from mechanical loading. Compression, tension, and torsion affect bone growth, dimensions, and shape in addition to the internal structure of the bones. Thus, functional asymmetries in movement can continue to develop through the viscous cycle of cause and effect between structural asymmetry and movement asymmetry. For example, bilateral differences in lower limb length can lead to asymmetrical walking and running patterns.

Development due to Lateral Preference and Motor Dominance

Bilateral differences in the dimensions of upper and lower limb bones, both in length and diameter, occurs due to differential stresses and strains relating to handedness. Thus, the long bones of the dominant upper limbs tend to be longer and thicker than those of the non-dominant limbs. While it might be expected that swimmers who have specialized in swimming from a young age and therefore have quite even stresses on both sides, many swimmers may have a history of participation in sports in which upper and lower limbs may have developed differentially due to favoring one side. Also, it has been found that the catch and pull phases of the front crawl stroke are longer for the dominant arm than for the non-dominant arm. The discrepancy is greater for sprinters than middle-distance and distance swimmers due to the sprinters seeking to apply larger forces with each stroke.

Asymmetries in shoulder roll often reflect breathing preference. These differences persist even when the swimmer is not breathing and the swimmers continue to roll more to the side that they normally breathe.

In addition to side dominance having a direct effect on swimming and the reinforcement of asymmetries through preferential use of dominant limbs, the possibility that swimmers may have uneven muscular development bilaterally due to the influence of other activities should be considered. For example, soccer players have weaker knee flexors in the preferred kicking leg than the non-preferred leg and muscle imbalance of the flexors and extensors of the preferred kicking leg is common. Thus, there is a possibility that swimmers who have played soccer recreationally, or have had a history of playing soccer prior to taking up swimming, would naturally have a bilateral difference in the vigor of the upbeat and downbeats of the kick. Although the opportunity for muscular development on both sides should be equivalent given the symmetrical nature of swimming, the bilateral differences inherited from other activities may be reinforced rather than removed due to unwittingly favoring the stronger muscles. Other examples may include increased strength of rotations about the long axis in a dominant direction arising from sports such as hockey, cricket, golf; increased strength in the dominant arm from work activities and sports involving throwing.

Further, asymmetries in fibre type and muscle innervation due to long term preferential use has implications for the fatigue rate characteristics of dominant and non-dominant sides. Thus, asymmetries may emerge with fatigue due to change in the relative contributions of the two sides. It has been found that the dominant arm requires less activation to perform a specific task than the non-dominant arm. The implication is that the dominant side is set up in terms of its neurophysiology to perform the same task with less energy expenditure than the non-dominant side.

Disease Factors

Disease factors can induce asymmetries in various ways including postural asymmetries, muscle imbalances and bilateral deficits, and flexibility limitations. These can influence the ability to generate propulsion, the ability to streamline, as well as the physiological capacity. Additionally, interactive effects are common. The effect in swimming is particularly detrimental due to the effects of misalignment of body parts on resistive drag. Structural and functional asymmetries increase the difficulty of balancing rotations of the body causing body parts to move out of alignment.

Children with cerebral palsy (CP) have muscle spasticity that increase stiffness and mobility. Bilateral differences in stiffness have a strong effect, particularly among those with hemiplegic cerebral palsy. From our observations of Paralympic swimmers with CP, the bilateral differences affect the capacity to balance propulsive efforts and to correct for unbalanced rotational effects.

Spinal asymmetries in the frontal plane such as scoliosis of the spine, and in the sagittal plane such as kyphosis of the spine, have an affect on performance via several mechanisms including muscular function, technique, and postural alignment. Scoliosis can result from neuromuscular diseases, congenital deformities and, more frequently, may develop independently of other disease mechanisms.

Single arm amputees develop asymmetrical strategies of coordination, in terms of the timing of the phases of the stroke cycle, to optimize performance. The strategy maximizes the propulsion gained of the unaffected arm while the affected arm adopts the role of maintaining stability. Similarly, many swimmers with a range of loco-motor disabilities develop extreme timing patterns to optimize performance in front crawl. Among veteran swimmers with Parkinson's disease, the increasing unilaterality of symptoms with progression of the disease creates increasing asymmetry in the movement patterns.

Effect of Injuries on Asymmetry and Muscle Imbalance

Asymmetries can develop as a consequence of injury. Further, the effects of the injury on symmetry can persist following recovery. This is supported by studies in which no initial asymmetry exists. For example rehabilitation of an injured shoulder is hampered by reduced activation and compensation by the unaffected limb. Swimmer's shoulder inevitably reduces the forces applied by the affected shoulder leading to asymmetries in technique as well as favored development of strength on the unaffected side and loss of strength on the affected side. The concern with swimmers returning from injury is that the compensation by the uninjured limb could persist and lead to development of technical asymmetries and inequitable contributions of limbs that are sustained and reinforced to become habit.

Overtraining and Fatigue

Overtraining is a general term that covers situations in which the training load does not allow sufficient time for the body to recover and repair itself for continued activity. From a physiological perspective it incorporates aspects relating to too high intensity and/or volume of training, inadequate recovery time, and increasing training load too rapidly. From a physical perspective it incorporates the inability for tissues such as muscles, cartilage, tendons, and protective sheaths to recover from the micro-trauma caused by training. This results in inflammation and release of enzymes that cause structural damage to the tissue and precipitates overuse injuries. Additionally, the soreness and loss of function reduces output of affected muscles and associated joints and limbs leading to asymmetries in performance and compensation by less affected parts.

While fatigue is a symptom of overtraining, some fatigue is normal and necessary to stimulate adaptive responses to training. Therefore, there are periods of swimming training sessions in which the swimmer's technique is affected by fatigue. These effects are considerable and are reflected in changes in many technique variables. The problem for the swimmer and coach is to ensure that the changes when fatigued do not become habit and a long term part of the technique. It is also essential that a swimmer avoids development of asymmetries during periods of fatigue that might become habit.

One goal of training for swimmers and coaches is to maintain good technical form, posture and alignment during periods of fatigue so that performance isn't adversely affected adversely by poor form in those areas in the closing stages of a race. This is likely to require attention to dry land training to correct imbalances in muscle strength and propensity to fatigue. Differences in fatigability are common between dominant and non-dominant sides. For example, the upper trapezius, important for maintaining good posture, fatigues more readily on the non-dominant side.

Technical Habits

Muscle function changes in response to the demands of the activity. In many sports there are considerable differences in the demands across sides of the body and between agonists and antagonists involved in the actions. This is most obvious in sports in which there are specific and different roles for different limbs and muscles. For example, long jumpers develop asymmetries in the joint torques of the takeoff and non-takeoff lower limbs and professional baseball pitchers have differing ranges of motion between the elbows of the dominant (pitching arm) and non-dominant arm.

In sports in which the shoulders are used forcefully through a large range of motion, such as swimming and kayaking, with no deliberate side bias, adaptive changes could be expected to occur evenly to both sides. However, the adaptive changes may not necessarily be entirely beneficial. Swimmers and coaches are very aware of the need to maintain shoulder joint flexibility to maintain performance and minimize injury risk. Thus, among serious competitive swimmers, the tendency to develop adverse adaptive responses to training may be largely offset by the emphasis on dry land training with appropriate strength and flexibility exercises.

However, in general, the maintenance of muscle balance may be achieved less well than the maintenance of shoulder joint range of motion. The technique in all swimming strokes involves pushing forcefully against the water with internal rotation of the shoulder. Conversely there is little use of external rotation against resistance. Consequently swimming tends to strengthen the muscles involved in internal rotation without equivalent strengthening of the external rotators.

Similarly, there is a tendency towards development of the pectorals, particularly in breaststroke swimming, leading to kyphosis. These muscle imbalances produce postural changes that may affect performance as well as predisposing the swimmers to shoulder injuries. Therefore coaches and swimmers must ensure that muscle balance is maintained by emphasizing training of the muscles that externally rotate the shoulder.

It may be difficult to assess whether asymmetries in stroke technique are the effect of laterality based motor development asymmetries resulting in muscle strength imbalances or, whether the volume required in high performance swimming activity is the cause of observed asymmetries. In any case, asymmetrical characteristics of technique are likely to reinforce or perpetuate the observed asymmetry and related outcomes including muscle imbalance.

One of the major asymmetries in front crawl technique arises from the natural tendency, related to side dominance, to favor one side when breathing. Thus, training should encourage symmetrical breathing patterns. Asymmetry related to side dominance is less among swimmers who breathe bilaterally.