SHORT REPORT

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The importance of agonistic, antagonist and synergistic muscles coordination on swimming dry land training

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Abstract
The best dry land workout exercises for swimmers are those that aim to develop performance, strength and flexibility but without compromising health. As there is no "one-size-fits-all" recipe, coaches should be very cautious when choosing a dryland workout regimen. In fact, due to the swimming cyclic and continuous characteristics, overuse affects (almost) every swimmer, reinforcing the role that land workouts should have in preserving and promoting swimmers health, and not contributing to the high prevalence of shoulder, low back and knee joint injuries. As competitive swimmers of any age should avoid dry land workout mistakes (that will leave them prone to injury), we will briefly present a new trend on agonistic, antagonist and synergistic muscles coordination to be applied in strength and mobility dry land training.

KEYWORDS: swimming, prevention, posture, mobility, proprioception.

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Swimming is a sport with a low rate of traumatic injuries (as fractures, contusions and sprains) since it occurs in the aquatic environment and swimmers compete one lane apart. However, nevertheless not being a contact sport (as competition occurs in separate lanes), swimmers frequently present severe injuries precluding them form persisting in daily swimming routines and competing [11, 18, 19]. In fact, it is relatively frequent that swimmers miss practice during some days or even weeks and, in extreme cases, drop out of the sport due to chronic pathologies. Some of them need, inclusively, surgical procedures to stop the pain, with this phenomenon occurring not only in adult but also in young swimmers [8].

As elite swimmers are engaged in two training units per day, six (or seven) days per week, typically training 10.000 to 20.000 m per day [7, 10, 17], they develop tendinitis, contractures and lumbago that are very painful and impeditive of continuing practicing [11, 18, 19]. Just after the early basic training period (after the age of 13 to 15 years old when integrating the main training group), swimmers repeat the same gestures thousands of times per week, looking for the best physical conditioning and technical perfection. However, those cyclic movements may predispose swimmers to overuse injuries, as the shoulder impeachment, low back and the hip adductor pathologies [7, 12, 15], if exercise is made with a less adequate muscular tonus and/or in an excessive range of motion.

Knowing that strength training is a key component in many sports (influencing abilities as power output, reaction time and agility), its inclusion in sports programs aims also for injury prevention [4], with swimming being no exception [10, 20]. However, considering that the land and aquatic environments (where strength workouts and swimming training occurs) have evident

different characteristics, planning a conditioning development program for swimmers should consider being very difficult to replicate out of the water the hydrodynamic drag effect [10, 16]. Indeed, functional muscle synergies depends not only on processes of self-organization, but also in the constraints (e.g. environmental) imposed on the neuro-musculoskeletal system [14].

As competitive swimming is one of the most worldwide popular sports, it is natural the existence of a huge interest in developing new strategies for efficient strength training programs for swimmers. Here the question arises: does the typical swimming dry land strength training prevent injuries induced by high number of movements' repetition, inappropriate muscular tonus and excessive range of motion? Some studies point out to numerous health benefits attained by individuals who engage in dryland swimming resistance training (form of physical activity that is designed to improve muscular fitness by exercising a muscle or a muscle group against external resistance) [2, 9], but is there any causal effect between those programs and the prevention of sports injuries? We believe that, nevertheless the importance given to the topic both by coaches and researchers [10, 20], the full link between dry land training and effective injuries prevention in such physically challenging training programs as those used in swimming has not yet been established. In fact, there are some suspicions that some of the recommended exercises will do more harm than good [13].

In this sense, knowing that chronic pathologies implies that swimmers suffer from pain during their workouts, limiting significantly their overall performance [7, 18, 19], we would like to raise awareness to some evidence-based data on the importance of body posture and core activation during competitive swimming. Our rational is based on the beliefs that: [3, 5, 6] (i) something is wrong if pain appears during the movement; (ii) first move well and only then move often (do not reinforce eventual muscle unbalances); and (iii) body strength depends more on the intermuscular coordination, i.e., in muscle synergies, than in the magnitude of contraction of each muscle per se. So, the first take-home message is that swimmers should have an articular mobility of good quality, not necessarily presenting high flexibility values achieved through increased isolated muscular length (the result of the traditional stretching workouts). The second important message is that when

Figure 1. Traditional vs body posture and core activation flexibility training (left and right panels, respectively). The circles represent serratus anterior allowing to increase articular mobility

performing the four conventional swimming techniques (front crawl, backstroke, breaststroke and butterfly) and corresponding starts and turns, swimmers should promote adequate agonistic vs antagonistic muscles coordination synchronized with synergistic muscles.

Regarding the first point, we should say that, from our own experience on the field, athletes with high flexibility levels usually present a relevant number of injuries due to articular wear. This evidences that, despite the augmented muscle length, if swimmers maintain a too high muscular tonus, the space between bones will diminish, leading to permanent articular compression. As an example of traditional flexibility training, when a swimmer performs a typical exercise as in Figure 1 (left panel), by stretching his dorsal muscle there is no absolute certainty if he is promoting the myosin-actin cross-bridges uncoupling or, eventually, ripping off collagen [1]. In fact, if a joint is fixed and compressed by muscles tension, its range of motion will be diminished due to the lower degree of freedom of the bones independently of the muscle stretching capability. In those cases, injuries can appear.

So, for a good quality articular mobility, and as a new trend on dry land workouts, we propose to stimulate the synergistic muscles that allow the joint to achieve a higher degree of freedom. Joints should be positioned in the maximal range possible using the synergetic muscles that stabilize the position and then, keeping the same amount of contraction all the time, mobilize it on the opposite direction. In the case of Figure 1 (right panel), swimmer should position the shoulder blade in "uncoaptation", activating the serratus anterior muscle and then, contracting the teres (major and minor) and the dorsalis muscles, promote a contraction against the resistance of the opposite upper limb. Briefly, while keeping all the time the same amount of contraction in the desired position of articular freedom, the opposite movement is done by an external load.

With the above-referred proposal, by developing proprioception, we are training the inter-muscular coordination, facilitating the antagonistic work by lowering the load that implies tension. This concept is related to the second take home message: an adequate agonistic vs antagonistic muscles coordination synchronized with synergistic muscles. When we want a movement to be executed by an agonist, the antagonist should be relaxed or at least be able to generate a good quality eccentric contraction [5]. So, we should train the antagonist to be fast relaxing or to realize an efficient eccentric contraction, otherwise we will retard the subsequent actions (and enhance joint tension). With this proposal, we better understand that swimmers dry land workouts should include the correct ratio between the agonist time of contraction and the antagonist relaxation time and/or the capacity of an efficient eccentric contraction. At the same time we are contributing to reduce the articulation compression, leading to prevention of overuse injuries, so typical in cyclic sports as swimming [12]. Proposing new trends in Sports Sciences and changing paradigms is a tough decision but, in our opinion, the right action in the long run. Swimming is a fun sport but a very high number of training hours is necessary to reach ambitious goals. As swimmers are engaged in physically challenging and prolonged training since early ages [10, 12, 17], it can increase the risk of illness or injury. However, if coaches apply dry-land training programs including correct body posture and core activation, it will be possible to prevent injuries and potentiate performance. This could be a fundamental action for developing swimming as a sport since there is a very significant dropout rate at adolescent ages, part of them due to acquisition of injuries. We hope that this short report will give new insights on preventive mechanisms of swimmers sports injuries (both for young and adult ages), particularly focusing of the preservation of their health status.

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