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Strength and Power Training of Australian Olympic Swimmers

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Introduction

AN OPTIMAL LEVEL OF STRENGTH and power is necessary for successful performance in many sports, and swimming is no exception. To compete successfully at the Olympic level, swimmers must include a year-round resistance training program to maintain or increase strength and power and reduce injury risk.

The strength and conditioning program at the Australian Institute of Sport has two principal design goals for the resistance training programs for swimmers: first, to develop strength and power to levels appropriate for the particular athlete, and second, to reduce injury by addressing any muscle imbalances and preexisting conditions specific to the athlete. In recent years, the injury prevention aspect has received increasing attention, principally because it enables the swimmer to undertake the high-volume sessions prescribed by the coaches while limiting the occurrence of overuse injuries and subsequent time out of the water. An emphasis is placed on shoulder joint stability and trunk rotational strength, taking in elements of core stability and segmental stabilization.

Performance Enhancement

Increasing sport-specific movement strength and power is very important for swimmers. The program should not be perceived as having the potential to produce excessive muscle hypertrophy. Swimming coaches believe that changes in body shape will increase drag force and this will be detrimental to swimming performance. This contention has not been supported or refuted by scientific research, but a priority of the strength and conditioning program is to work harmoniously with the coaches, and their opinions are taken into consideration. A program that has the potential to produce an outcome that the coach considers undesirable will be rejected. The education of the swimming coach in this area is vital. In truth, the athletes do not have the time to devote to a resistance training program with sufficient volume to produce large increases in muscle size since they complete so many hours training in the pool. It is very unlikely that more than modest gains in muscle size could be achieved in these

athletes regardless of the resistance training program. The large volume of endurance exercise that swimmers complete each week is incompatible with maximal gains in strength and muscle size, and past research (6) suggests these conflicting influences will limit muscle hypertrophy. In fact, an important goal of the strength program is to maintain muscle size in an effort to counteract the high volumes of pool training.

Based on the research, it is clear that athletes can produce increases in strength and power in response to appropriate resistance training without a gain in muscle size (11). These improvements in strength and power can be attributed to an increase in the ability to recruit and synchronize the firing of their motor units (11) as well as changes in intracellular factors such as myosin heavy chain composition and enzyme activity (1, 3). Consideration of these adaptations and the manipulation of program variables form the basis of a strength and conditioning program for swimming. The majority of swimmers within this program do not need a hypertrophy type of program, but there are certain times where muscular size increases are required. For example, it may be difficult to realize increases in strength and power for an athlete with very low muscle mass. Female swimmers especially can be in need of carrying more muscular size in the upper body. Although increases may occur due to neural and intracellular adaptations, these increases may be greatly enhanced with prior increases in muscle size. What the optimal level of muscle size is for such gains is not known for the sport of swimming.

Specific training for muscular endurance, a critical component of swimming performance, need not be a part of a strength and conditioning program for swimming. Rather, the strategy is to get the athletes stronger and more powerful and leave the development of muscular endurance for the in-water training. Different methods of training to produce this effect are programmed by the swim coaches themselves and can range from kick sessions to just arm-pull sessions. If maximal strength and power are increased, then a given submaximal muscle contraction will be at a lower relative intensity, and endurance should be increased once the athlete has expressed their increased strength and power in the pool. Core stability also plays a vital role in the swimmer's preparation because the swimmer has to stabilize the trunk to produce force with the upper and lower limbs.

Although there is no empirical data to support this, the coach and athlete should be made aware that, upon initiating a resistance training program, there might be declines in skill performance due to fatigue and muscle breakdown. This effect should quickly dissipate if it occurs at all. Research has shown that increasing muscle strength may initially result in a decrease in performance of the target skill (2). The athlete will have to modify the control of the neuromuscular system, commonly referred to as coordination, timing, or technique, to actually produce an increase in in-water performance. In order to take full benefit of an increase in muscle strength, coordination needs to be adapted, which has been termed "tuning." This is not a problem in swimming because muscle strength training programs are always accompanied by considerable swimming training, which allows the athletes to practice with their changed muscles. In addition, strength endurance is not emphasized in the resistance training programs for swimmers because they already complete an enormous volume of swimming and overuse and overtraining syndromes are always a risk.

It is in the weight room where improvements in an athlete's strength and power are predominately generated. An appropriate program incorporating the correct exercises can improve the in-water results attainable from strength and power training. The programs written are straightforward and are the same for both male and female swimmers. Individual variation occurs when an injury issue is identified or musculoskeletal screening has identified a muscle imbalance. Different swimming stroke specialties (i.e., freestyle, backstroke, butterfly, and breaststroke) have different exercises associated with them.

Injury Reduction

Shoulder girdle etiologies are one of the most prominent injuries a swimmer encounters (4, 10). The main cause of the shoulder injury is overuse. Tendonitis mainly occurs in the swimmer's rotator cuff

Table 1
Strength Quality Regime

Type	Reps	Sets	Intensity (%)	Rest
Power	1–3	3–4	90–100	3–5 min
Maximum strength	1–6	3–4	85–100	2–5 min
Strength endurance	>12	3–6	40–65	30–90 s
Hypertrophy	8–12	3–6	65–80	30–90 s

Table 2
General Introductory Program

	Set 1	Set 2	Set 3	Set 4	Set 5
Session 1					
Lat pulldowns	8	8	8	6	6
Single-leg press	6	6	6	4	4
Alternate D/B bench press	8	8	8	6	6
Single-arm seated row	8	8	6	6	
Rotator cuff	8	8	8	8	
Twisty machine	8	8	8	8 each side	
Abdominals (see below)					
Session 2					
Chin ups	8	8	8	6	6
Reverse back extension	8	8	6	6	4
Single-leg squat	6	6	4	4	4
3-way back	8	8	8	6	
Med ball kickback	6	6	6	6 each arm	
Woodchopper (figure 1)	8	8	8	6	6
Abdominal (see below)					
Session 3					
Chin ups + weight	6	6	6	4	4
Leg press	6	6	6	4	4
Alternate D/B bench press	8	8	6	6	6
Lying cable pullover	8	8	6	6	
Twisty machine (Figure 2)	8	8	8	8 each side	
Single-arm seated row	8	6	6	6	8
Abdominal session					
Abdominals		200 reps from below			
Swiss ball					
Crunches		2 × 20			
Russian twist		2 × 20			
Leg tucks		2 × 20			
Lateral roll		2 × 20			
Med ball					
Side pass		2 × 10 each side			
45 Degree sit		2 × 30			
Overhead throws		2 × 20			
Twists		2 × 20			

Notes: Week 1, do all sets and reps. Week 2, do all sets and reps and add lower rep set. Week 3, do only first 2 sets—higher rep sets only. Week 4, do as much weight as possible on last lower repset.

and usually can be addressed by increasing the strength of the external rotator muscles and the stabilizing muscles around the scapula (13).

The cause of the inflammation or tenderness around the rotator cuff is typically the large volume of training, with some days amounting to over 14 km being swum. This results in considerable internal rotation strength and thus a relative weakness in the external rotators. The muscle imbalance combined with overuse makes shoulder injury a common malady of swimmers. Some studies have shown that this is more prevalent in butterfly and freestyle swimmers than in backstroke and breast stroke swimmers (5) due to the pull-through phase of these strokes causing significant impingement. This difference has

Figure 1. **(a) Start, (b) intermediate, and (c) finish positions for the woodchopper exercise.**

been identified and programmed for correction. This is accomplished regardless of their specialty stroke because a large percentage of the high volume of training is done in freestyle mode. Therefore, all of the swimmers are put on remedial exercises to prevent an injury occurring or developing a major imbalance that will eventually cause injury.

Designing A Program

When designing a resistance training program for competitive swimmers the following must be considered:

- Goal of the program—hypertrophy, maximum strength, maximum power, strength endurance.
- Number of reps—depends on goals (see Table 1).
- Number of sets—depends on goals (see Table 1).
- Rest between sets—depends on goals (see Table 1).
- Choice of exercise.
- Order of exercise.

All of the above will depend on the equipment available, number of athletes in the weight room, and the training age of the athlete. The goals of the program change throughout the year as the athletes get closer to major competitions. The focus of macrocycles shifts from strength to power and endurance as the competition draws closer.

It is necessary to adjust the repetition range and number of sets required to produce adaptations in each muscular quality. Problems have occurred in the past when the incorrect repetition range has been prescribed. For example, a program designed to increase muscular endurance in swimmers that involves using 10 repetitions per set would not be the most appropriate to achieve this goal. This type of training will predominantly increase the lean muscle mass of the athlete, a hypertrophy training effect. Another mistake

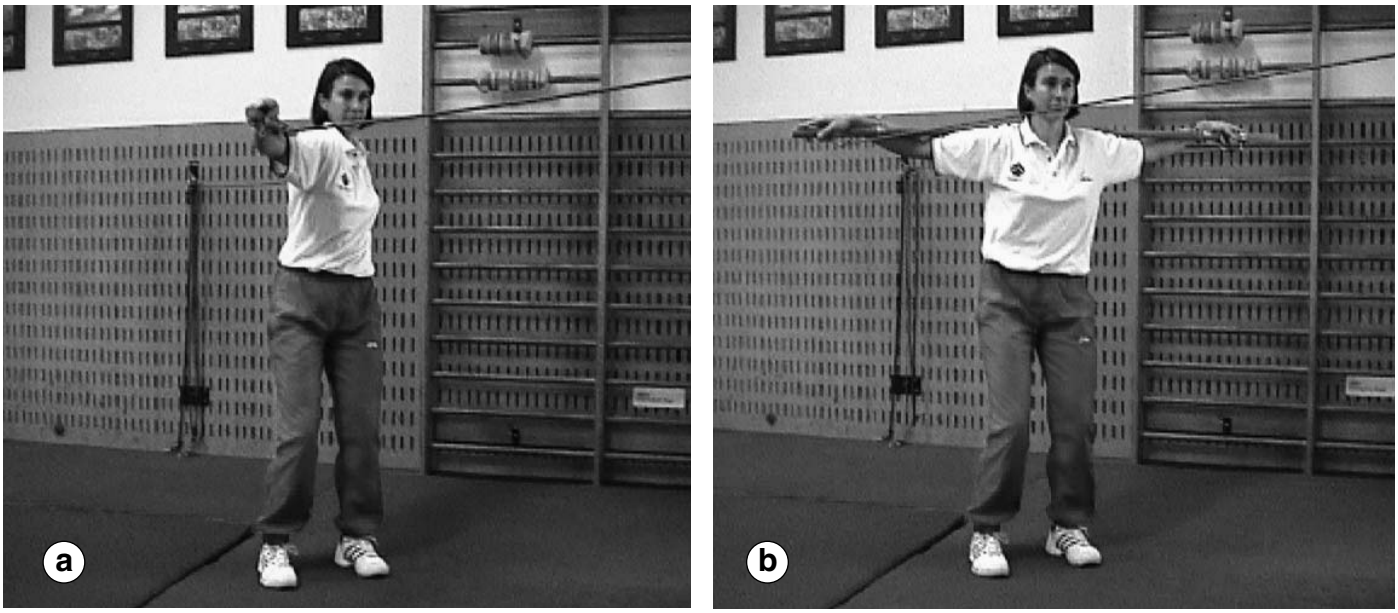

Figure 2. **(a) Start and (b) finish position for the twisty machine exercise.**

by many swim coaches is to prescribe sets of 8–12 repetitions, assuming they are building a strength base when in fact they are inducing a body building effect. As discussed previously, hypertrophy training may only be required when a swimmer of slight build requires extra muscle mass. At this time, it might be prudent to limit endurance activity and instigate a phase with the principle goal of maximizing the hypertrophic response. Given the conflicting requirements of the swimming coach for in-water training, this situation might be difficult to achieve.

The success of any resistance program depends on the accurate identification of muscle groups and joint actions used in the sport. To determine which exercises will be of benefit to the swimmer, a qualitative biomechanical analysis of each stroke includes

1. Joint actions.
2. Muscles recruited.
3. Contraction mode—the type (concentric, eccentric, isometric) and speed of contraction.
4. Strength quality required—maximum strength, rapid force development, maximal power (9).

The exercise that is most specific to the target movement will be the best exercise to select because of the greater carryover effect to improved in-water performance. Using this method, several core exercises are chosen and written into the program. Other exercises are selected for the program on the following bases:

- Prevent muscle imbalances developing between prime movers and antagonists.
- Prevent injury to prone areas such as the shoulder.
- Increase core stability and thus gain greater trunk rotational strength.
- Provide variety.
- Suit the skill level of the athlete.

In the past, many programs have only concentrated on specific movement patterns and muscle groups involved in swimming instead of first building a general strength base from a wide range of overall body exercises. It has been well documented that the use of resistance training has produced changes in bone (7) and connective tissue density (8). This is very important for the swim athletes because they spend a large part of their day in a non–load-bearing state during normal training. Thus, to prevent "dry land" injuries, establishing a general strength base through resistance training is an important injury-prevention method.

There are many methods that are used to organize the exercises within a given training session. Some of the more practical methods are

- Exercises progressing from large to small muscle groups.
- Alternating upper and lower body exercises.

Table 3
Sample Resistance Training Program for Justin Norris
200-m Butterfly, Sydney 2000 Olympic Games

Warm up
5 min, bike
10 squat jumps, 15 med ball standing side passes, 10 dips, 15 med ball single-arm passes
Rotator cuff, internal and external rotation and multidirectional
Core stability, progressions from coach

Days 1 and 3	**Set 1**	**Set 2**	**Set 3**	**Set 4**
Inward/outward rotation at catch	8	8	6	6
Isometric squats	6	6	6	4
Chin ups with weight	8	8	6	6
Alternate D/B bench press	6	6	6	6
Gluteal/hip machine	8	8	8	8
Twisty machine (Figure 2)	8	8	8	8
Swim bench	20 s	20 s	20 s	20 s
Abdominals (see below)				
Days 2 and 4				
Med ball pullovers	6	6	6	6
Alt D/B bench press	8	8	6	6
Single-arm lat pulldowns	8	8	6	6
Single-leg squats on spring w/board	6	6	6	6
Body blade, prone on bench	8	8	6	6
Traveling lunge	6	6	6	6
Med ball chest pass on Swiss ball	6	6	6	6
Abdominals (see below)				

Abdominal session	
Abdominals	200 reps from below + static-hold exercises
Swiss ball	
Crunches	2 × 20
Russian twist	2 × 20
Leg tucks, single leg	2 × 20
Bridge	2 × 30
Own selection	2 × 30
Static hold	30 s in all 4 positions
	30 s in all 4 positions with feet on foam roller
Med ball	
Side pass	2 × 20 each side
Overhead throws	2 × 30
Twists	2 × 30
Lower abs	2 × 30
Med ball to feet crunches	2 × 30

Notes: Four positions for static hold are start position, left side, right side, and then supine (see Figure 3).

Table 4
Sample Resistance Training Program for Petria Thomas, 200-m Butterfly, 1996 Olympic Games; 200-m Butterfly, 2000 Olympic Games.

Warm up
5 min, bike
10 squat jumps, 15 med ball standing side passes, 10 dips, 15 med ball single arm passes, 10 walking lunges, 15 back extensions.
Rotator cuff, internal and external rotation and multidirectional
Core stability, progressions from coach

Days 1 and 3	**Set 1**	**Set 2**	**Set 3**	**Set 4**
Internal/external rotation at catch	8	6	6	6
Squat jumps	6	6	6	4
Alternate cable pull	8	8	6	6
Gluteal/hip machine	8	8	8	8
Alternate reverse fly	8	8	8	8
Arm curls	10	10	8	8
Abdominals (see below)				
Days 2 and 4				
Clean pulls from block	6	6	6	6
Alternate D/B bench press	8	8	6	6
Single-arm lat pulldowns	8	8	6	6
Chin ups	6	6	6	6
Body blade	20 s	20 s	20 s	20 s
Depth jumps (20 cm)	8	8	6	6
Wrist curls	8	8	6	6
Abdominals (see below)	8	8	6	6

Abdominal session
Abdominals — 200 reps from below + static hold exercises

Swiss ball
Crunches — 2 × 20
Russian twist — 2 × 20
Leg tucks, single leg — 2 × 20
Bridge — 2 × 20
Own selection

Static hold — 30 s in all 4 positions
30 s in all 4 positions with feet on foam roller

Med ball
Side pass — 2 × 20 each side
Overhead throws — 2 × 30
Twists — 2 × 30
Own selection

Note: Four positions are start position, left side, right side, and then supine (see Figure 3).

- Alternating agonist and antagonist.
- Working high priority muscle groups before lower priority muscle groups,

Free weights and cable machines are used as much as possible. Exercises that incorporate the use of dumbbells and cable weight stacks, and to lesser extent barbells, strengthen not only the prime mover musculature but also the stabilizing muscles surrounding the joints involved in the movement (12). The control required when

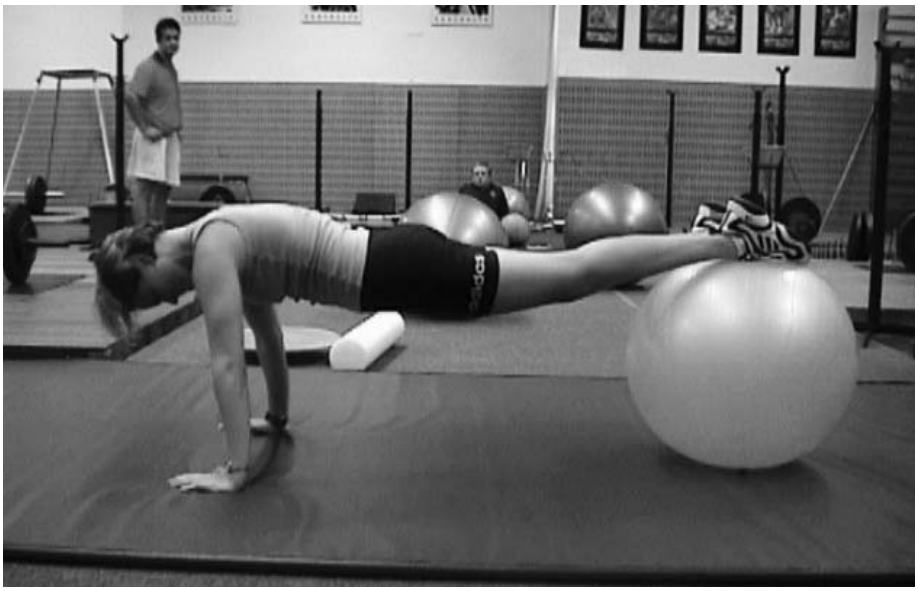

Figure 3. **Start position for static hold exercise.**

using dumbbells is much greater than when performing exercises on a machine where the movement and plane of motion is set.

Sample Programs

The first program (Table 2) is designed as an introductory program for the start of the swimming year. The goal of this program is to increase the strength in the swimmers' shoulders while also trying to increase their general strength level (Figures 1 and 2).

The next program (Table 3) was designed for Olympic medallist Justin Norris. The emphasis of this program is to provide the swimmer with a good strength base to enable him to carry out the volume of training. Justin did not have a large resistance training background. The program is designed to increase his strength in the shoulder girdle and to stabilize his pelvic trunk area. Justin suffers from strong internal rotators of the shoulder with weak external rotators. Justin also needs strength in his kick and better triceps strength.

The next program (Table 4) was designed for Petria Thomas, a sprint butterfly swimmer. The emphasis of this program is twofold. Petria has very mobile joints, and as such, it is an important goal of the resistance training program to increase the stability in her shoulders while also emphasizing the development of strength. Here again, we have the dual emphasis of performance enhancement as well as injury prevention/rehabilitation.

In a periodized progression, the training program will change before a swim meet to emphasize neural activation. This is designed to help swimmers in the taper process to be more coordinated and be able to deliver forces where they need it. Samples of these programs are not included because good coaching communication is needed and technical feedback a necessity for results to be achieved.

Summary

We do not live in an ideal world, and the strength and conditioning specialist working with the swimming athlete must contend with a wide range of competing and conflicting factors. It is vital that all swimmers resistance train to increase strength and power for improved swimming performance and to provide adequate strength for them to cope with the rigors of high volumes of in-water training. The program must address any muscle imbalances or prior injuries to assist the athlete to remain pain and injury free. ▲

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