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SPRINT-USRPT: TRAINING FOR 50-m RACES

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SPRINT-USRPT: TRAINING FOR 50-m RACES

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Sports Science Associates

and

San Diego State University

A Coaches' Manual for the

Cherrybrook Carlile Swimming Club

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TABLE OF CONTENTS

Sections and Titles		Page
	Preface	**0.1**
1	**INTRODUCTION**	**1.1**
2	**SURFACE-SWIMMING TECHNIQUE**	**2.1**
	Body/torso and Head Streamline	2.2
	Quick and Minimal Breathing Action	2.4
	Coordinated Shoulder and Hip Roll	2.5
	Timing (Index of Coordination)	2.7
	Stroke finish/Exit Position	2.9
	The Power-phase (Mid-stroke)	2.11
	Stroke Entry/Initiation	2.13
	Arm Recovery	2.15
	Kicking	2.17
3	**RACING SKILLS TECHNIQUES**	**3.1**
	The Dive	3.1
	Position on the block	3.2
	Dive trajectory	3.3
	Arm movements	3.6
	Summary of features	3.7
	Transition from the Dive	3.8
	Angle of entry and slowing due to turning	3.8
	The shallow vs. deep dilemma	3.10
	The character of double-leg kicking	3.11
	Surfacing	3.12
	Determining how many double-leg kicks should occur	3.12
	Surface Swimming to the Approach to the Finish	3.13
	Approach to the Finish	3.14
	The Finish	3.15
	The Turn for a Short-course 50-m/y Race	**3.16**
	The Approach	3.16
	The Turn	3.16
	The Transition/Break-out	3.17
	Racing Skills Practice	3.17

Continued over

TABLE OF CONTENTS

Sections and Titles		Page
4	**PERFORMANCE PSYCHOLOGY**	**4.1**
	Performance Enhancement Imagery	4.2
	Performance Enhancement Imagery Components	4.3
	Coping Behaviors	4.7
	Coping examples for anxiety and negative thinking	4.8
	Coping content for readiness and arousal	4.8
	Race Build-up Strategy Content	**4.10**
	Build-up Strategy Components	4.10
	Comfortable stretching	4.10
	Keep active	4.10
	Do not be distracted	4.10
	Isolate from others	4.11
	Concentrate on the task	4.11
	Performance enhancement imagery	4.11
	Gradually neglect distant segments	4.11
	Positive self-talk	4.11
	Physical pump-up	4.12
	Rinsing the mouth with a carbohydrate solution	4.12
	Emotional pump-up	4.13
	Focus on start with maximum intensity	4.14
	Race Build-up Routine Example	4.14
	Race Build-up Strategy Preparation	4.15
	Race Strategy	**4.17**
	Segment the Performance	4.18
	Task-relevant Content	4.18
	Mood Words	4.20
	Positive Self-statements and Self-talk	4.21
	Integrating Strategy Components	4.21
	Coping Behaviors	4.21
	Psychological Intensification	4.22
	Recovery	4.23
	Debriefing	4.24
	Learning Race Strategies	4.25
	The Overall Goal of Competing	4.25
	An Example of a 50-m Race Strategy	4.26

Continued over

TABLE OF CONTENTS

Sections and Titles		Page
5	**CONDITIONING**	**5.1**
	Programming Content	**5.3**
	Warm-up	5.4
	Basic Parameters of Training Sets for 50-m Swimmers	5.4
	The structure of a set	5.4
	Terminating participation in a set	5.5
	15-m repetitions	5.7
	25-m/y repetitions	5.9
	50-m/y repetitions	5.9
	Training for 100-m/y races	5.9
	Individual skill practices	5.10
	Formats	5.10
6	**CLOSURE**	**6.1**
	Constant Motivation to Improve	6.1
	Directed thought Content	6.2
	Sprinter's Character	6.3
	Standard-USRPT Modifications	6.4
	Sprint-USRPT Effects	6.5
	Land-training	6.5
7	**REFERENCES**	**7.1**

PREFACE

It is a reasonable question to ask *"Why a USRPT book on 50-m sprinting?"* There are numerous reasons for such a specialization. Below are some of the more salient features that distinguish the shortest race in swimming from all the others.

A 50-m freestyle event is over very quickly. If errors or inefficiencies occur in the sprint their impacts will be immediately obvious. In longer races, there is time to recover from less than perfect segments. Their extended nature and often repetitious segments allows for in-race corrections with the result being a minimizing of the effects of problematical swimming. However, if errors/inefficiencies are a normal part of a swimmer's performance, their cumulative effects will produce a very poor performance. On the other hand, the performance of a 50-m race requires a variety of racing skills and an attempt to sustain a very efficient form of surface swimming. There are no repeated segments within the race. Consequently, to achieve the highest level in the sprint all facets of the race need to be performed perfectly. If errors or inefficiencies occur there is no opportunity to correct or offset them within the race. That can only be done in subsequent training and in the next race. Errorless totally efficient sprinting requires the perfect execution of all skills and technique. To achieve one's best performance in a 50-m race, a perfect race has to be executed. Training and competing have to be obsessively oriented toward perfection in all facets of the event. That is a feature that differentiates 50-m racing from all other swimming events.

When seeking perfection in a race, training has to be oriented toward a continual drive to improve in all race-relevant activities. Opportunities to improve, such as removing inefficiencies or maximizing propulsive actions, need to be sought. In the pursuit of perfection there is no time where less than one's best effort can be tolerated. It takes a special athlete and coach to strive for perfect performance. One underlying variable that governs the attainment of perfection is the knowledge of what needs to be achieved. That is one of the reasons this manual covers all facets of 50-m performance – surface swimming technique, racing skills, pre-race and race strategies, and a modified form of USRPT for conditioning the athlete to the highest level. The understanding of and drive for perfection requires a particular mind-set at practices and competitions. The intensity of focus on analyzing skills and technique, facilitating improvements in race-relevant factors, and maintaining motivation is more extreme than for other swimming events. That is a feature that differentiates 50-m training and racing from all other events.

The specificity of training needs to be strictly observed if the enormity of the number and complexity of racing skills and technique are to be achieved. Swimmers can do so much training work before a level of fatigue is experienced which from then on precludes any further advantageous learning or skill modification. A finite amount of training can be experienced at practices before the session's involvement should be terminated and full recovery facilitated. The amount of time required to attain specific perfection depends on the work and recovery attributes of the swimmer and the coach's competence in instructing cyclic skill elements (i.e., the technique of surface swimming) and the motor skills that are required in a race (e.g., the dive, the transition from the dive to surface swimming, the approach to the finish, and the finish itself). Short-course 50 y/m races are more complex than long-course races because of the need to perform a turn halfway through the event. The specificity of training is the paramount underlying characteristic of successful sprint training.

A distinguishing characteristic of 50-m training is that every movement and skill attempt has to be performed at maximum speed. As seasons of training progress, an incessant focus on performing any race-relevant activity faster than before needs to exist. That is not so for all other swimming races where less than fastest swimming velocities are practiced usually to learn race-relevant pacing. There may be a need for a coach to specialize in 50-m race coaching. The type of feedback provided a swimmer determines the rate of skill progression in swimmers (de la Fuente & Arellano, 2010). It is not good enough for coaches to provide qualitative feedback (e.g., *"that was improved"*, *"the transition was faster"*, etc.) for sprint-race training elements. Swimmers react better to objective measures of performance which means the actual time for every trial at practice. The training feature of continuous objective performance feedback could expose the limitations of a coach. When training performances cease to improve no matter what the coach explains, describes, or suggests as avenues for improvements, a swimmer's confidence in the coach is likely to deteriorate rapidly. Coaches of sprinters will have to become students of the race and always seek valid new information that has been shown to result in improvements in progress velocities. The training and competitive performances of 50-m race segments and the entire event will be as much a reflection on the quality of coaching as they are of a swimmer's competence.

Speed of movement is the underlying factor governing sprint-swimming performances. One can commonly hear coaches extolling the virtues of trying harder, increasing the effort intensity, using strength gains, etc. However, as it is in track and field and speed skating, it is appropriate for swimmers to concentrate on moving faster to progress through the water faster. The effort level to achieve speed should be quite high but not excessive. It has been shown that if a swimmer achieves maximum velocity and increases the effort level further no increase in swimming velocity results from the *harder* effort (Capelli, Pendergast, & Termin, 1998). At high effort levels, performance improvements are more likely to occur through more precise technique emphases than extra effort. How one teaches the difference between *trying harder* and *trying faster* depends upon many factors, most of which are brought to the 50-m training session from swimming practices that encourage a work ethic aimed toward *working harder*. Training for 50-m races should be differentiated from other training by the emphasis on speed of movement (power), a factor not involved with strength.

There is no practical relationship between force and the ability to produce force quickly. Moving quickly and producing force quickly may be related only to a small degree. The current emphasis on improving strength to improve movement speed should not yield much change because the two capacities have so little in common (Gardner *et al.*, 2007). Costill (1998) authoritatively presented conclusions about the effects of land-training: *"You can gain strength by swimming. If you want to overload the muscle then do sprint swimming"*. Traditional supplementary training other than swimming is unlikely to improve muscle power for swimming. The intensity of exercise involved in USRPT has been shown to improve muscle hypertrophy and contraction speed (Losey *et al.*, 2013). An incessant coaching emphasis on movement speed in race-relevant activities should benefit 50-m performances.

The physiology of 50-m racing is different to all other swimming races. If a swimmer has the physiological capacity (stored oxygen) to complete a race without breathing, performances will benefit. The act of breathing increases turbulence around a swimmer (resistance) and progress is slowed slightly. Even when breathing actions are minimized, slowing still occurs. Performing when only stored oxygen is available for metabolism is termed *hypoxia*. Thus, it is desirable to not breathe at all in a race. The training for hypoxic performances by doing extra hypoxic exercises does not work any better than normoxic training (Truijens *et al.*, 2002). Adaptation for 50-m racing is best achieved by practicing all race-relevant activities without breathing.

Another major training feature for 50-m racing is the amount of rest provided in the USRPT format. For all other swimming events, between-repetitions rests are regulated and time-limited. Eventually, in normal USRPT fatigue accrues and performance deteriorates to being slower than race-pace and the exercise is terminated. In sprint-race training, between repetitions rests are as much as can be provided to produce as close to total recovery as can be achieved in a practical setting. That requires a vastly greater amount of recovery time in relation to work time when compared to the standard USRPT format. When a set of sprint repetitions is engaged, repetitions are continued until performance slows. That first indication of deteriorating performance is the hallmark of USRPT because it signals neural fatigue. Training beyond neural fatigue produces slower swimming which is an irrelevant training pace. It does not benefit competitive performances. Training for segments of a 50-m race requires as near as possible complete recovery between repetitions which differentiates it from the standard restricted-rest USRPT.

The above items set the training parameters for 50-m racing as being different to those of all other swimming events. Those differences emphasized the need to write this manual and warrant terming the modified form of USRPT as *Sprint-USRPT*. It is hoped that the content of this volume will promote improved coaching for and swimmer performances in 50-m races.

As an addendum, it should be mentioned that the features of surface-swimming technique, technical aspects of racing skills, and the scope of performance psychology are also appropriate for 100-m swimmers. Only the conditioning features would change with the intensity of the majority of work being race-pace and the rest periods in 25-m repetition work being ~15 seconds. Some of the 50-m conditioning work could be quite beneficial for 100-m swimmers. A major difference for conditioning would be that the 100-m swimmers would have to train and race up one distance (200 m).

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August 5, 2017

Section 1
INTRODUCTION

This manual is intended for coaches and swimmers who specialize in 50-m swimming races. Usually, it will be relevant for single or very small groups of swimmers. What it advocates would be almost impossible to use with over-crowded lanes of age-group swimmers.

Racing 50 m in crawl stroke is different to longer-distance swimming events in several ways.

- A 50-m race requires the perfect execution of every facet of the pre-race activities, the technique of surface swimming, the technique executions of the non-swimming race skills (e.g., dive, transition, wall approach in the turn in 50-SCm races, etc.), and control over the mental skills employed in the event. There simply must be no errors in a 50-m race.
- A 50-m race is hypoxic because there should be no breathing involved once the water has been entered. Consequently, the amount and utilization of stored oxygen is a major physiological feature to enhance in training.
- Stroke rates are highest in 50-m races and therefore require the development of a technique that fosters an opportunity to exert as many propulsive impulses as possible. As well, diminishing both resistance and inertial lags in propulsion as much as possible are equally important.
- Technique is not as efficient in 50-m racers as it is in swimmers who race longer distances (Reer *et al.*, 2007). However, it is easy to comprehend why seeking to maximize propelling efficiency is a valuable strategy for any swimming event. If technical ways exist that promote a swimmer to move through the water faster and in a more efficient manner then they should be followed no matter what the distance raced.

Since swimming velocity is determined by stroke rate and stroke length, the critical factors in these relationships are stroke rate, oxygen availability, and stroke length. Changes for the better in any of these factors while the others remain stationary or improve will result in improved performances. However, it would be incorrect to emphasize one factor and not monitor/consider the others (Wakayoshi *et al.,* 1995).

The reason this discussion focuses on crawl stroke is that it is the only stroke over 50 m that is scheduled in Olympic competitions. The other strokes are accommodated at world championships. For those strokes, the surface swimming techniques and racing skills will have to extracted from Rushall's 2011 and 2013a books. However, there still is considerable commonality between that which is presented here and the strokes not discussed.

The task of race-pace training is to extend the performance envelope. The technique for 50 m should be to apply ballistic forces so that there are no deliberate delays in the stroke cycle, to develop propulsive forces over the longest effective distance possible in the direction of intended progression, and use the greatest surface area of the arm to create maximum drag forces over the effective propulsive stroke distance. Those are the guidelines for the development of propulsive forces in surface swimming. Added to the surface-swimming stroke form are other racing skills (e.g., the dive; the transition from the dive to surface swimming; the approach to the turn; the rotation of the swimmer in the turn; the most explosive drive off the wall possible; the turn features to involve continuous movements; the transition to surface swimming; the approach to the finish; the final finish strokes; and wall touch). As well, the preparation on land before the dive in the race should be executed enthusiastically and accurately. The sum of those features implies that anything involved with the preparation for and the execution of a 50-m race has to be performed perfectly. Any error will cost a swimmer time and so the aim of any 50-m event is to produce a perfect race.

Dr. Erik Risovalto (personal communication, July 26, 2015) proposed the following features as being common between a 50-m race and the remainder of competitive swimming events with regard to USRPT. The commonalities are:

1. Researched-based training;
2. Agreement with the theory of specificity;
3. Adherence to laws of physics;
4. Strict focus on technique and skills as the most important coaching emphases;
5. Ultra-short race-pace interval training, with strict athlete-fail protocols and specific physiological recovery events;
6. Recording written and video data to evaluate athlete performances and progressions;
7. Reviewing gold-medal data for comparison of progressions and technique improvements when physically correct;
8. Notable cyclic progressions and adaptations;
9. Zero traditional dry-land theoretical and irrelevant activities;
10. Mental focus and skills training;
11. The absence of anything that cannot be proven to have direct effect on race performance at race pace; and
12. Every effort is related to race-pace performance and competitive situations.

The technique, skills, and psychological features of USRPT are the most important factors for 50-m training. This presentation is divided into four sections: 1) surface-swimming technique, 2) racing skills techniques, 3) pre-race and race activities, and 4) physical conditioning activities.

Section 2

SURFACE-SWIMMING TECHNIQUE

Most of the features discussed here are extracted from Rushall (2013a). The proportion of a 50-LCm race that is surface swimming is 70%. For 50 SCm, the proportion drops to a minimum of 40%.[1] Contemplating those figures should make one aware of the importance of non-surface swimming skills in these short races.

The development and alteration of surface swimming technique, hereafter referred to as *technique*, requires correct instructional strategies (i.e., pedagogical structures). If they are not followed and actions to change techniques are attempted on an *ad hoc* basis, it is likely that desirable changes will not be achieved. Two major strategies must always be contemplated when considering technique alterations.

1. *The center-to-periphery principle.* Alterations of the arms and legs should only be considered after the swimmer's in-water posture (the body-head position) is correct. If there is an error in body/head position it may well be that the faults in the arms and/or legs are simply reactions to the more central body-part errors. For example, if the head is high, then a considerable part of the arm stroke will need to produce vertical force components to supply the force to maintain a high head position. If the arm forces are more than necessary to sustain an erroneous head position, some kicks will need to be over-emphasized to counterbalance those excess vertical forces by creating their own excess vertical forces so that the main trunk of the swimmer will be streamlined.

   Before any arm or leg alteration is attempted, the coach has to ensure that the streamline of the body and head is maximized. A common question to oneself should be: *"Are the arms doing that as an error or are they simply reacting to sustain a poor body/head position?"*

2. *The backward-shaping procedure.* Instruction is more effective and learning is faster when the first element in a movement chain is the last element taught (Rushall & Ford, 1982). That means the first element instructed is that which terminates the chain. In crawl stroke, when working on the propulsive phase of the stroke the first focus of instruction should be the positions of the arm segments at the end of propulsive acceleration and before an arm's action rounds-out to begin the recovery. The advantage of backward over forward shaping progressions is that in backward shaping every element presented is oriented to completing the stroke correctly. Always finishing a stroke correctly influences the dimensions of every new element instructed in a positive manner.

In this discussion, the technique elements described will be in the order that conforms to the above two pedagogical principles. The first four segments concern the center-to-periphery principle, the next three concern backward shaping of the propulsive arm stroke action, the second last element is the recovery (mainly a cosmetic factor), and the last element concerns kicking. The full discussion of those elements is in *A Swimming Technique Macrocycle* (Rushall, 2013a).

[1] These percentages are based on the assumption that some swimmers will exploit fully the 15-m distance after dives and turns that are permitted for underwater swimming using double-leg or alternate-leg kicking.

The order of presentation in this article and the Rushall (2013a) book is also the order of decision-making when reviewing a swimmer's video to determine what technique modifications are required. For example, one would not alter a segment of the propulsive phase of one arm if the swimmer's body/head position was incorrect. The strong possibility exists that if the arm action was altered and then the body/head streamline improved, there would be a further change in the arm action caused by the body/head modification, negating what was achieved with the previous arm alteration. The center-to-periphery principle is always in effect and coupled with Newton's Third Law (*"To every action there is an equal and opposite reaction"*) when making technique alterations. Any technique is the result of various forces (passive and active resistances) so that a change in force production by any part of a swimmer will cause some other part of the swimmer's technique to react/change. Technique modifications cannot be made in isolation within a swimmer. One always has to consider what will be the reaction elsewhere in the swimmer's technique that will result from a change. By following the center-to-periphery progression of changes a coach can hedge against altering the body/head posture in the water in some detrimental way. If an aspect of an arm or kicking action is changed, the reaction should take place in the other arm or part of a kicking action and not disrupt a swimmer's streamline, breathing movement, or body/hip roll.

The order of technique development is as follows:

- To reduce resistance:

  i. Body/torso and head streamline.
  ii. Quick and minimal breathing action.
  iii. Coordinated shoulder and hip roll.
  iv. Timing (Index of Coordination).

- To increase propulsion:

  v. Stroke finish/exit position.
  vi. The power phase (mid-stroke).
  vii. Stroke entry/initiation.

- Potentially disruptive action segments:

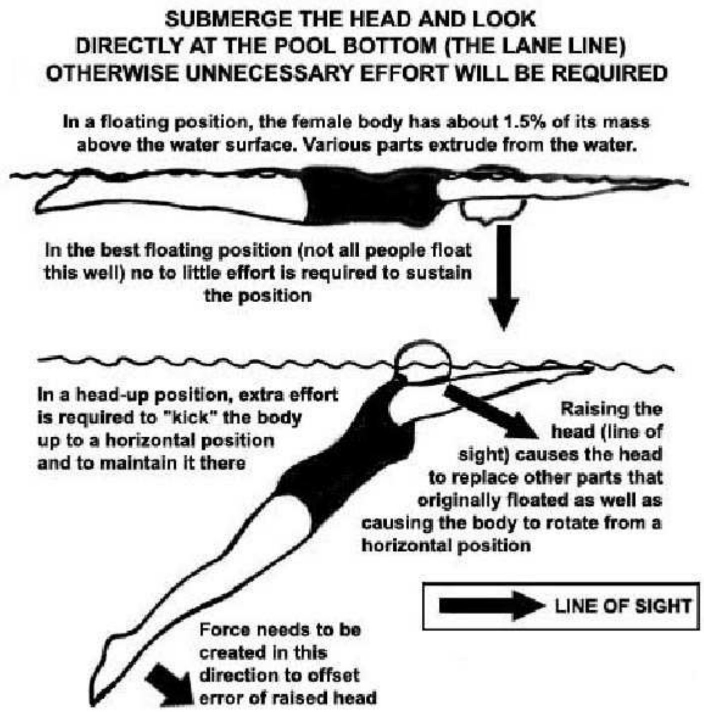
  viii. Arm recovery.
  ix. Kicking.

The first four technique elements are aimed at reducing resistance. They are the easiest and most common ways to gain a performance improvement (Cappaert, Pease, & Troup, 1996). They require no extra effort on behalf of the swimmer, only technique changes. They are essential for all swimmers. Research has highlighted them as being the major technique items that differentiate champions from lesser performers (Stewart & Kagaki, 1998).

Body/torso and Head Streamline

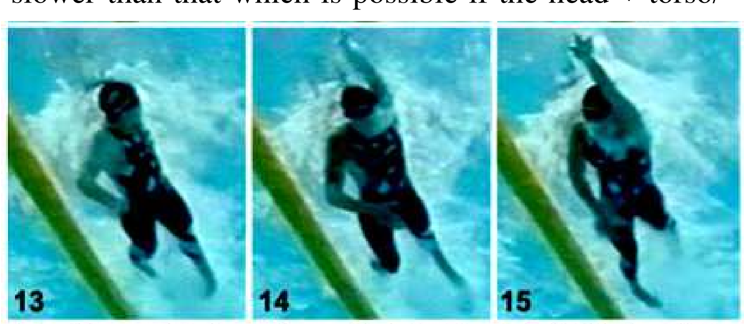
The body/torso and head, the non-force-producing posture of the swimmer, should be aligned to form the least frontal resistance possible. As well, the bumps and troughs of a swimmer's surface also should be aligned in streamline so that turbulence will be formed from previous turbulence which results in minimized surface resistance. The characteristics of a proper swimming posture that will minimize all resistances are:

- The head should be down with the eyes looking directly at the bottom of the pool.
- The head depth should be such that some water travels over the swimmer's cap.
- The top of the swimmer's buttocks should be at the same height as the upper most part of the swimmer's head.
- The postural line between a swimmer's head and buttocks should be firm along the horizontal axis.



The most common error that increases resistance is when the head is raised and the vision orientation is fully forward or at an angle (see diagram to the right). The ideal position for floating is horizontal (the top figure). However, because the centers of buoyancy and mass are not aligned, a horizontal position is unnatural except in very rare cases. The body rotates until it reaches an angle where the two centers are aligned. That is the natural floating angle. An angled position is often caused by crowded training conditions when forward vision is constantly used to avoid collisions. It eventually becomes a swimmer's habitual body/torso + misaligned-head swimming posture. Any hyperextension of the neck will cause the hips to sink in the water – a simple result of Newton's Third Law. The angling increases body frontal and wave resistances. However, the hips can be maintained at streamline if the size of the kick is increased to produce extra vertical forces that counterbalance and sustain the raised head position. The problem with enlarging the kick is it increases resistance as does a degree of head elevation or angled face. Both faults, the raised head and the excessive kick, increase frontal and wave resistances.

One should not ignore the head position. An elevation or face angle prevents a correct and resistance-minimized breathing action (see below). As well, the extra resistance caused by a misaligned head and torso (even if the torso is streamlined), means that the terminal velocity (i.e., maximum swimming velocity) is reduced. The increased resistance plus that caused by other errors or swimming speed, will be slower than that which is possible if the head + torso/ body position is fully streamlined.



Dara Torres winning a Silver Medal in the 4 x 100 Medley Relay at the 2008 Beijing Olympic Games

The picture to the right shows Dara Torres with an acceptable head position for sprinting. However, even that could be improved. In the middle frame, there is turbulence coming off the face which is extra resistance that causes the swimmer to slow and restricts terminal swimming velocity.

The face should be rotated sufficiently downward, so that no turbulence comes off the face. Unfortunately, few swimmers perform with a minimal-resistance face/head position.

When the head is *down* and *flat*, water should break over the scalp causing the bow-wave to be reduced. As well, the amount of bow-wave reduction also cancels out some of the shoulder-wave (the secondary bow-wave caused by the shoulders) that is created (Rushall, 2013b; Wikipedia, 2013). To judge whether the head is in a good position, the coach should monitor the size of the lateral wave that breaks away from the head when swimming in undisturbed water. Watching how big is that wave is best done by assessing its size relative to the lane ropes. An aim should be to make that wave as small as possible.

Quick and Minimal Breathing Action

In a long-course 50-m race, swimmers should aim to complete the event without breathing. In breaststroke and butterfly, the number of strokes performed without breathing should be many more than would occur in a 100-m race. In backstroke, breaths can be taken but the swimmer should aim to take as few as possible. The reason to not breathe is that every freestyle breathing-stroke slows the swimmer. In the above sequence of Dara Torres in a breathing stroke in a 100-m relay leg, one of the slowing factors, the creation of unnecessary turbulence off the face, is clearly evident in Frames 14 and 15.

In the case where a breath has to be taken through some miscalculation on behalf of the swimmer, the crawl-stroke breathing action should adhere to several criteria.

- The head turn should be independent of the shoulder turn and recovering arm.
- The turn should be minimal with inspiration occurring at the bottom of the bow-wave through the upper portion of the mouth. Unnecessary extra movement such as lifting the head, turning the face forward as part of the head-turn, etc., should be avoided
- Breathing-out should be explosive as the head starts to turn to the side on the horizontal axis.
- Inhalation should be fast when the mouth is just clear of the bottom of the bow-wave and returned to look at the pool bottom very quickly (before the recovery arm is vertical).
- The turning action should be timed with the arm exit (the stroke-phase of least effort).
- Streamline should be maintained at all times throughout the breathing movement.
- The postural line between a swimmer's head, shoulders, and hips should be firm along the horizontal axis.

In a short-course 50-m race involving a turn, it often is advantageous to take a very quick breath before the turn (i.e., one or two strokes before the rotation). The turn requires very different muscular actions and energy sources to what is required in surface swimming. A breath can contribute two functions. First, it can serve as a signal (a *trigger*) that it is the beginning of the turn sequence which requires movements at maximum speed. Second, the addition of extra oxygen should allow the swimmer to perform faster movements and a definite explosive drive off the wall as well as beneficial double-leg kicking in the transition after the explosive drive. When a swimmer is developing an oxygen debt, isolated explosive or fast actions are compromised. The turn sequence is a series of isolated actions. That differs to the cyclic action of the surface-swimming crawl stroke where velocities should be maintained for a significant proportion of the race.

Not breathing will eliminate the resistance and slowing caused by the breathing action. It should always be the aim of a swimmer to practice and race with no breathing. If a breath is required, it should be as small and fast as possible. Some practice should be devoted to performing appropriate breaths according to the criteria listed above ostensibly for use with entry into a turn.

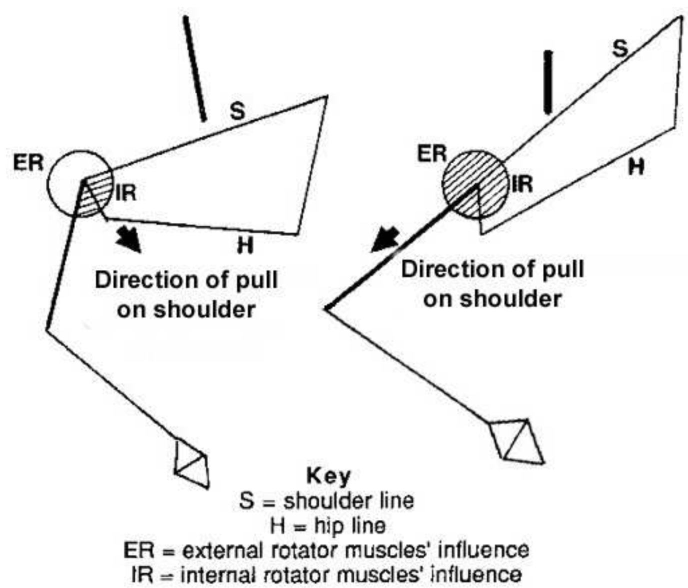
Coordinated Shoulder and Hip Roll

In an analysis of Olympic swimmers at Barcelona in 1992, elite crawl-stroke swimmers were found to have a symmetrical shoulder-hip roll while non-qualifiers produced opposite and less hip and shoulder roll. Elbows were high early and were maintained high throughout the stroke. The power of elite and non-qualifiers' pulls were similar but the better streamlining (less resistance) of the elites produced greater propelling efficiencies (Cappaert, Pease, & Troup, 1996). That research testimony emphasized the importance of lessening resistance as the first priority in the development of swimming technique.

Keppenham and Yanai (1995) investigated shoulder and hip roll in skilled and unskilled swimmers. They found the coordinations of the initial arm movement, body roll, and strong beat kick were different between the groups.

- Skilled swimmers rolled the shoulders and hips together during the strong beat kick. Unskilled swimmers rolled the hips first and then the shoulders.
- Skilled swimmers executed the strong beat kick after entry 2% into the stroke time while unskilled swimmers waited until 13% of the stroke duration had passed.
- Skilled swimmers entered the recovery arm when the body roll was greater than 40 degrees (9% of stroke time after attainment of the maximum shoulder roll) while for unskilled swimmers the entry occurred when the body roll was less than 0 degrees (20% of stroke time after attainment of the maximum shoulder roll).
- The body roll was not a continuous fluid motion. The roll remained on the side while the strong beat kick was executed. This suggests that for a considerable part of the arm pull underwater, the body is on its side.

Shoulder to upper-arm angle. The figure below and on the right illustrates two alignments of the upper arm and shoulders in the crawl-stroke propulsive phase. In the left figure the shaded portion of the circled shoulder joint indicates that the internal rotator muscles (IR - the anterior deltoid, pectoralis major, and latissimus dorsi) are activated more than the external rotators (ER - the infraspinatus, teres minor, and supraspinatus) resulting in a minor inward movement of the greater head of the humerus to irritate the glenoid labrum (leading to the injury known as *swimmer's shoulder*). In the right figure, the alignment of the humerus and the shoulder rotation allows both IR and ER muscle groups to function in *"balance"* so that the



shoulder joint works correctly, produces no irritation, and more muscles are used to produce propulsive forces.

With regard to propulsion, an angular change at the shoulder joint that favors one group of rotator muscles over the other means that fewer muscles are used to generate and sustain force. Those fewer muscles will fatigue easier than if more muscles were used to generate the same amount of force. Thus, not only is a swimmer threatened by injury with an angled shoulder pull (Ruwe et al, 1994), the mechanical and endurance properties of the resulting action also will be degraded.

The desirable technique feature of the upper arms in crawl stroke, when combined with shoulder rotation, is to have the two aligned. The recovering arm should also be aligned in the manner displayed for the propulsive right arm. This could be an important technique criterion for effective crawl-stroke swimming. In crawl stroke, maintaining a high-elbow[2] recovery becomes difficult with fatigue. If the recovering arm is lowered as a race progresses, it is likely that shoulder/hip roll will decrease. Particularly in crawl-stroke races, as fatigue increases, the conscious effort to maintain a high-elbow recovery should concomitantly increase.

Frontal Resistance. The relationship of the two lines S (shoulders) and H (hips) should be understood. These data are extracted from Cappaert and Rushall (1994). In the left figure which illustrates when the shoulders are not rolled much, the hips roll little if at all and in some cases might even tilt past horizontal (as illustrated). The frontal area in low-angled shoulder-roll is the area with S and H on opposite sides. When that area is compared to the right figure S-H area, its area is larger. The desirable angle of shoulder-hip roll is in the vicinity of 45°. As well, the propulsive arm is positioned better to exert more shoulder power, and the lower arm can attain a desirable elbow flexion of 90° or more (Rouard & Billat, 1990).

The shoulders and hips should rotate to the same degree to each side. The amount of rotation with each arm-pull/recovery should be the same.

The three-frame picture to the right shows Libby Trickett during a world-record 100 m swim[3] rotating the shoulders and hips to the same degree as well as illustrating the upper-arm to shoulders alignment that facilitates using both internal and external rotator muscles in the upper arm's abduction and adduction phases of its contribution to actions that produce propulsive forces.

Libby Trickett at 40 m of Her World Record 100 m Freestyle Race at the 2008 Australian Olympic Games Swimming Trials

A correct coordinated shoulder-hip roll facilitates a longer arm stroke, the development of greater propulsive forces, and minimizes resistance from the torso and legs. Since the hips roll,

[2] It is assumed that the reader knows that a high-elbow recovery with the forearm hanging down in a relaxed manner is the best form of recovery for two reasons. It is easier to perform than a lower or wider recovery (a bigger angle at the elbow) and it centers the force application of the propulsive arm because there is only a small lateral force component to be counterbalanced.

[3] Very few underwater videos are available of top swimmers competing in 50-m races at very important meets. The technique elements of 100 and 50-m races are very similar with the main difference being the higher rate in 50-m events.

the legs' kicking actions will oscillate from side to side rather than always being vertical in the manner practiced when isolating kicking with a kick board.

The main features to be stressed in body/hip roll are:

- Body roll consists of the hips and shoulders rotating to ~45° to both sides. That reduces frontal resistance and positions the propelling arm closer to the mid-line.
- In crawl stroke, a high-elbow recovery will facilitate good body roll.
- In the arm-pull, the power produced by the external and internal shoulder rotator muscles should be emphasized.
- In the middle of the propulsive phase of crawl stroke, a line from the recovering elbow through both shoulder points to the propelling-arm elbow should be straight.

Timing (Index of Coordination)

Chollet, Chalies, and Chatard (2000) developed an Index of Coordination (IdC) which looked at the relationships of one arm's propulsive action to that of the other. Three indices were developed.

- *Catch-up Timing in Crawl Stroke*: There is a period of time between successive propulsive phases where no propulsive forces exist (lag-time) and the swimmer slows. The velocity curve is wave-like but demonstrates negative values during the lag-time.
- *Opposition Timing in Crawl Stroke*: When the propulsive phase of one arm finishes the other arm begins. The velocity curve of this coordination is wave-like, falling to lower levels between the loss of propulsion in one arm and the building of propulsion in the other.
- *Superposition Timing in Crawl Stroke*: When the propulsive phase of one arm is finishing, the other begins. The overlap of reasonable levels of force application produces a wave-like velocity curve with only a minor dip in each wave.

The three IdCs yield numbers that indicate their effectiveness. The catch-up timing is decidedly negative. The opposition timing ranges from slightly negative to low positive. The superposition timing yields mainly positive numbers, although in the overlap between the indices, when superposition is barely perceptible from opposition, it might yield a very low positive value. High positive numbers should be sought by 50-m performers.

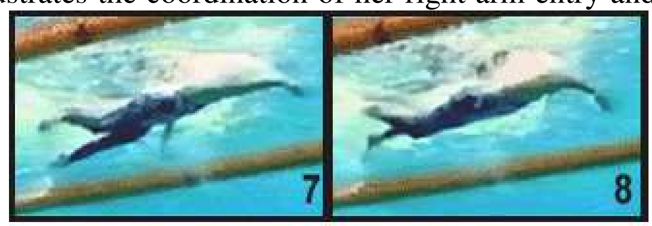
The main factor that was considered was what happened between the finish of one arm's propulsion and the initiation of propulsion of the other. Although commonly coached and seen in some of the better distance swimmers, particularly males, the catch-up stroke is particularly inefficient with inertial lags between strokes that result in considerable slowing. As swimmers increase their velocity, the catch-up stroke is gradually replaced by either opposition or superposition coordination. Many sprinters demonstrate the opposition timing. As one arm ends its propulsion, the other arm begins to build its propulsion. The difficulty with that timing is that the propulsive forces are very low at the time of change-over. That stage of weak propulsive force still allows the swimmer to slow but certainly not as much as in the catch-up stroke. The third IdC, *superposition*, is desirable for 50-m performers. As one arm nears the end of its propulsive phase, the other arm begins its propulsive phase. There is a brief period where both arms propel the swimmer which minimizes any slowing due to the diminution or absence of propulsive forces. The superposition timing is advocated for 50-m swimmers. Chatard *et al.,*

(1990) showed that the superposition of arm actions favored better swimming efficiency in better skilled swimmers.

The picture to the right shows Alexandre Popov executing a superposition of the timing of the left arm entry and right arm exit. The notable feature is the entry where the elbow and wrist of the left arm bend immediately upon entry. Some swimmers begin the repositioning bend before the actual entry.

Alexandre Popov at 35 m of His 50 m Silver Medal Race at the 1998 Perth World Championships

The picture of Inge De Bruijn to the right illustrates the coordination of her right arm entry and left arm exit. It is difficult to tell if this is a true superposition or a very good opposition coordination.



Inge De Bruijn at 30 m of Her Winning 50 m Freestyle Race at the 2000 Sydney Olympic Games

One way of fostering the superposition timing might be to increase the stroking rate primarily by recovering as fast as possible. When a swimmer rates very high for him/her there usually is a shortening of the length of the stroke (Barden, Kell, & Kobsar, 2009). However, the length of stroke has two interpretations. The first is the most common concept of the length being where the hand of one arm enters and exits the water. The second is an older and more meaningful interpretation indicating *effective length* as being where propulsion starts and ends with the arm underwater. This second interpretation is favored by this writer. When stroke rate is raised, there need not be any change in effective length but if the entering arm is bent before breaking the surface, the common concept of length of stroke would be deemed to have shortened although it would begin propelling sooner than a straight arm entry or over-reach forward.

Theoretically, increasing stroke rate by recovering faster is not the best way of achieving a higher rate. A more sound approach would be to move faster (i.e., explode) at the entry and the repositioning of the forearm/hand surface (see Alexandre Popov Frame #12 above) and then accelerate faster during the propulsive phase. Those elements are discussed below in more depth.

Huot-Marchand *et al.* (2005) showed that stroke length and stroke index cannot be considered as the only parameters linked to improvement in high-standard swimmers. An increase in stroke rate associated with a slight decrease in stroke length should not be considered as ineffective, especially at high standards. It was also suggested that the benefits of stroke length become maximal and that increases in stroke rate provide the avenue for higher levels of attainment. Although those factors were considered for 200-m swimming, they are equally applicable to 50-m sprinting.

To achieve a desirable form of timing, the following features should be accommodated.

- The propelling arm is bent all the time and never straightens.
- The intent of the propulsive arm movement is to have the whole surface of the arm (the upper and lower arm and hand) push backward against the water.

- The path of the propelling arm is mainly horizontal and certainly should not go deep.
- The propelling arm pulls under the swimmer, not with a long arm outside the line of the propelling shoulder.
- Rate should be as high as possible by attempting an explosive entry followed by a marked greater acceleration during the propulsive phase of the stroke.
- The elbow of the propulsive arm should be flexed at least 90° at mid-pull.

The above side-headed factors reduce resistance and in the case of timing coordination, reduce inertial lags (periods of no propulsion). They need to be developed. They require no extra effort from swimmers; only technique changes. Consequently, the ability of swimmers to develop these four features is dependent upon the ability of the coach to instruct effectively and to engineer as much reinforcement as possible at practices as contingencies for assuming the positions and actions described. These four features need to exist in swimmers' techniques before work commences on arm propulsion.

The two pictures following are of Erik Risovalto, former US National Junior Champion and now representing Puerto Rico as a 50-m specialist. On both sides the entering hand is moving directly to a propulsive position while the propelling arm is still in a productive stage. These are examples of superposition timing despite the propelling arms needing some corrections.

The most important feature of swimming performance is the application of forces that directly produce propulsion, that is, a swimmer's propelling efficiency (D'Acquisto & Berry, 2003).

The underwater propulsive actions of a crawl-stroke swimmer are taught in a *backward shaping* format. Commonly, coaches almost universally attempt to teach the technique of propulsion from the start to the finish. The difficulties with the forward progression have been discussed elsewhere (Rushall, 2011; Rushall & Ford, 1982). In keeping with the reverse progression format, the first element to be instructed is the finish position for the arms. Instructing that element first means that once learned, swimmers should always attempt to complete a stroke correctly. With that aim in mind, errors made earlier in the stroking sequence will be limited to a greater extent than if no terminal action of the propulsive movement was known to the swimmer. The following features should be evident in a correctly-finished crawl-stroke arm pattern.

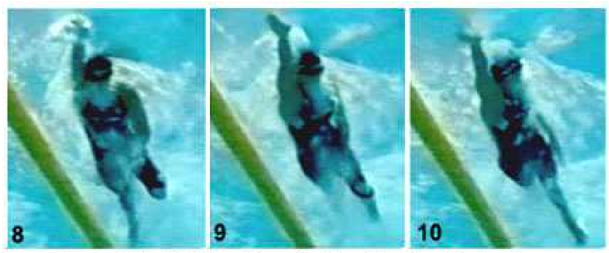
- This part of the arm stroke should feel the strongest and fastest part of the total-arm movement. It marks the end of propulsive acceleration.
- The adducted elbow should be as far back as possible alongside the swimmer.
- The forearm and hand should be vertical and pressing directly backward.

- The next movement after achieving the arm's end/final position should be the elbow being raised out of the water to initiate the arm's exit.
- The hand and forearm should *"round-out"* as they exit the water.

Two sensations should precede the attainment of the finish position.

- The body should be moving fastest past the arm(s) at the end of the stroke. The corollary to that sensation is that the swimmer should feel he/she is moving fastest away from the anchored arm than at any other time in the stroke.
- The sensation on the arm of pressuring (forcing) the water should be consistent or marginally higher at the finish than at any other stage in the stroke.

The above sensations are dependent upon the swimmer understanding and seeking to execute acceleration of the propulsive movement. The force created by the arm just prior to the exit should be the greatest of any stage of the *"pull"*. That facet will have to be instructed to be able to achieve the correct finish position. Only when the finish position and acceleration prior to attaining it have been achieved should the next element of the propulsive movement be introduced. Chatard *et al.* (1990) investigated swimming skill and stroking characteristics of front crawl swimmers. They argued that the stroke pattern should emphasize the last part of the underwater stroke rather than the entry.



Dara Torres' Finish Position in Her Medley Relay Leg Swim at the 2008 Beijing Olympic Games

The picture to the right shows Dara Torres' finish position. In Frame #8, there is a large area of turbulence (low pressure) in front of her left arm indicating that the forces being created are quite large. It is assumed that accelerating in the pull has led to that force production. In Frame #9, the upper left arm is by the swimmer's side and fully adducted. The lower arm and hand continue to move through minor flexion at the elbow. That leads to the arm being angled relative to the vertical plane. If that did not occur, the arm would produce considerable drag resistance for a brief period until exited. In frame #10 the elbow and upper arm have exited the water assisted by shoulder roll. The forearm/hand trails and exits in what is termed a *round-out* action, which preserves some of the momentum created in the arm during the pull. That momentum facilitates the recovery.

Inge De Bruijn's Finish Position in Her Gold Medal 50 m Race at the 2000 Sydney Olympic Games

The illustration to the right shows Inge de Bruijn's finish at 30 m of her 50-m Gold Medal race at the Sydney Olympic Games. Similar features to those of Dara Torres are evident. In Frame #1, turbulence is in front of the right arm. Frame #2 shows the finish position with the upper right arm parallel to the surface and close to the body. The elbow is flexed to ~90°. Frame #3 shows how quickly the exit and round-out of the right arm occur. In one tenth of a second, the exit was accomplished.

After instructing the correct finish position, the coach should always monitor underwater videos to ensure it is always attained in concert with the four previous technique points. Since swimmers will be asked to accelerate the arm during the pull, this technique feature requires effort on behalf of the swimmer.

Formosa, Mason, and Burkett (2010) demonstrated the importance of representing active drag as instantaneous force, rather than a mean value. That provides unique and valuable insight into the intra-cyclic force fluctuations within a stroke cycle. For the practitioner it verifies that it is of greater importance to improve the last phase of the crawl stroke (where forces are greatest) than the first phase. That implication contradicts the values that are often claimed for *"front-quadrant"* swimming.

The Power-phase (Mid-stroke)

Swimming stroke power is delivered not by strength but by an accelerated arm movement. To produce the greatest power, the following criteria need to be evident in the pulling phase of the propelling arm.

i. Develop direct horizontal force components. Lateral and vertical force components should be minimized.
ii. Produce the longest effective stroke distance possible.
iii. Employ as many muscles as possible by rolling the shoulders and hips together so that the internal and external rotator muscles of the shoulders can produce adduction and abduction of the upper arm. As well, the elbow should be flexed at least 90º as early as possible and retained as long as possible in the stroke.
iv. Acceleration of the force development should proceed through the effective pull range and be highest at the finish position.

The following features should be evident in a correct power-phase movement in crawl stroke.

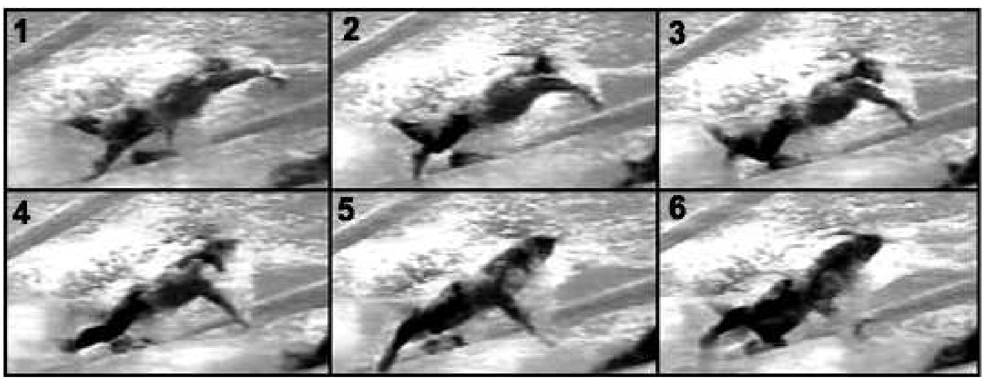
- This part of the arm stroke should feel increasingly faster and stronger as acceleration is developed.
- At the beginning of an effective pull, the forearm/hand should rotate to be vertical while the upper arm medially rotates and remains stretched forward on an extended shoulder.
- As the upper arm abducts, the shoulder and hip should be at the deepest point of the body roll.
- As the upper arm adducts, the shoulder and hip should have rotated upward.
- The finish-position should be attained as the recovering arm enters the water.

The propulsive-phase is the most complex of the segments that comprise the swimming stroke. The arm and shoulder positions need to be achieved as far in front of the swimmer as possible. That requires unnatural movements in the upper arm (medial rotation while held extended forward accompanied by outward rotation of the lower angle of the scapula, and the repositioning of the hand-forearm as a unit to be vertical. Acceleration is achieved primarily through the forces created by the shoulder muscles through a full range of abduction and adduction of the upper arm. During that phase, the hand-forearm surface should be kept at right angles to the line of direction of intended progression. That requires a swimmer to concentrate on moving the elbow and mid-forearm together as opposed to the traditional orientation of the hand. The forearm actually produces more force than the hand (Cappaert in Troup, 1992) and therefore, warrants more attention than the hand which can be used simply as an extension of the forearm.

The challenge for crawl-stroke swimmers is to situate the limbs and shoulders in such a manner that the power-phase can be executed effectively. In the figure below, Alexandre Popov's right arm displays all the features that accelerate a swimmer through the propulsive phase. This figure is derived from his Gold Medal swim in 2003.

In Frame #1, the stroke starts far in front of the swimmer with the shoulder extended forward. That results in commencing propulsion and acceleration from well in front of the swimmer and should result in the longest effective pull for that stroke.

- In Frame #1 the right arm has entered the water and is being repositioned to where extensive propulsive forces can be initiated quickly from a far-forward position. The left leg kicks to counterbalance the vertical force component of the entry and preceding movements. The extended arm shows some wrist bend and the start of elbow flexion. In this frame the real movements that are occurring are: a) medial rotation of the upper arm to hold the upper arm steady; and b) elbow flexion to initiate the lower arm's path to become vertical. The hand leads the lower arm by being slightly flexed at the wrist. [This section of Popov's stroke is in opposition timing. The propulsive shoulder is deep. The right arm is starting propulsion while the left arm has completed its propulsion and is exiting.]



- Frame #2 shows medial rotation of the upper arm and holding the upper arm forward on an extended shoulder. More elbow flexion increases the angle of the forearm/hand unit. The right shoulder remains deep. The alignment of the upper arm relative to the line through the shoulders is clearly visible. The movement of the upper arm is powered by the internal and external shoulder rotator muscles.
- Sometime after Frame #2 abduction of the shoulder occurred. In Frame #3, because of the many muscles employed in the *"full-shoulder"* stroke, abduction and the following adduction are very powerful movements. The elbow joint is flexed to an angle slightly less than 90º and is aligned at 90º to the direction of propulsion.
- Frame #4 depicts almost at mid-stroke. In this position, strong abduction is being completed, and the whole arm – the upper and lower segments and hand are presenting the largest surface area possible to pressure the water and produce force. All sections of the arm are at right angles to the intended direction of progression. The shoulder and hip downward rotation keeps the *"line of propulsion"* close to the swimmer. The right leg kicks to counterbalance the forces being exerted by the recovering left arm.

- Frame #5 shows little change in the arm's position from the last frame. The swimmer's propulsive surfaces are thrusting powerfully and directly. The shoulders and hips have rotated together.
- Frame #6 approaches the end of the stroke. The body begins to rotate quickly upward and the elbow draws into the right side to complete adduction. The forearm/hand is largely vertical and at right angles to the line of propulsion. The swimmer should feel he/she is moving faster than at any time in the propulsive sweep; that it has accelerated him/her from a slower start to significant velocity at the end; and once the end-of-stroke position is achieved, a round-out exit occurs with no break in the overall movement velocity.

Perhaps the greatest change in this description of the propulsive stroke-phase from traditional descriptions of technique is the use of the total arm as a propelling surface. For established swimmers that reorientation usually is challenging but it must be achieved if performance standards are to be improved.

There are several faults that are commonly observed with the propulsive phase of a stroke.

i. The arm pulls long with only a minor amount of elbow flexion. The long arm goes very deep and so the forces created are largely vertical (going down and coming back up to exit) and relatively weak when compared to a 90º flexed arm (Rouard & Billat, 1990).
ii. The long arm pull is outside of the shoulder line of the swimmer. The distance to the side usually is at a maximum in the center of the pull. Being to the side, a force moment is established and has the capacity to push the swimmer to the side (much like rowing a boat using one oar). To keep the swimmer on a direct line down the lane, a force needs to be developed to counterbalance the pull's lateral forces. Normally, that occurs through executing a kick (the size of the kick determined by the size of the moment) in the middle of a six-beat kicking action.
iii. The pulling action starts from a long deep arm forward of the swimmer. Apart from that arm creating resistance, it takes a small amount of time before the arm catches up to the speed of the water leaving the effective propulsive pull quite short. As well, with the arm deep in the later part of the pull, the exiting movement of sliding the arm vertically shortens the propulsive phase further.

Stroke Entry/Initiation

The time between touching the water and developing a greater horizontal force component than vertical component needs to be as short as possible. Three factors are important to gain an understanding of what needs to be done at and just after entry into the water after a recovery.

i. *An inactive arm is a resistive arm.* An inactive (non-propulsive) arm develops resistance (usually frontal and surface resistances) and is detrimental to a swimmer's progress. When an arm enters the water, it is desirable for the time it takes to reposition the arm to produce an effective pull be as short as possible. An arm in the water should be active and performing propulsive movements and not resting, gliding, sculling, etc.
ii. *Minimize inertial lags*. This concept is akin to the previous principle. An inertial lag is the length of time between the finish of one arm's propulsive phase to the start of the other arm's propulsion. This concept pertains to the role of the arm(s) underwater. An arm should be producing forces that accelerate a swimmer. Stroking patterns should be developed such that the time from entering the water to the development of horizontal

force components is as short as possible. That will minimize the time when only resistance to progress exists.

iii. *Maximize the effective pull.* Swimming efficiency will be high if the length of the effective pull, that is the distance over which the swimmer is accelerated, is the greatest possible. Developing stroke initiations as far as possible in front of the swimmer and *"powering"* to correct finish positions should maximize the length of an effective pull. Achieving that concept will go a long way toward developing swimming excellence.

The implications of these three principles are clear:

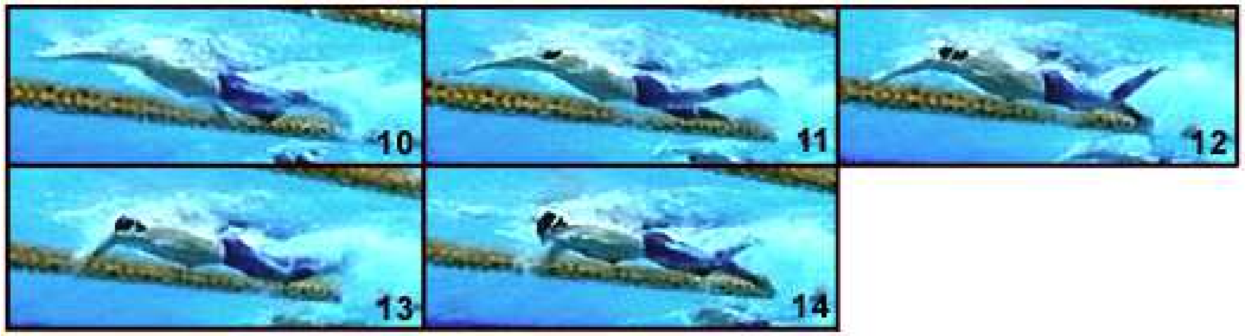
i. The time taken from entering the water to propelling the swimmer should be the shortest possible;
ii. Upon entering, immediate repositioning actions of the arm should occur so that propulsion starts after the least delay;
iii. The orientation for the start should be to establish the power-phase with the most direct and fastest movements possible; and
iv. The power position should be established as far as possible in front of the swimmer and continued through to an exact finish-position.

A corollary of these implications is: *Perform no unnecessary movements or delays underwater.* Chatard *et al.* (1990) argued convincingly that gliding and excessive stretching under water after the entry should be minimized so that deceleration between individual arm cycles does not occur.

Two problematic situations affect the ability of a swimmer to achieve an effective force position in the shortest time possible.

i. If a swimmer kicks too large, it might be impossible to do a correct repositioning action. With many large kickers, the time it takes to execute six big kicks takes longer than it does to complete a full stroke cycle. This is termed *"kick-dominant"* swimming. There are no advantages to big kicks, only disadvantages.
ii. Often associated with kicks that are too large are the initial movements of the arms after entering. It is very common to see the arms kept straight, instead of immediate flexion of the elbow(s). Stroke entries are the major cause of shoulder injuries (Yanai & Hay, 1996). When the arm is straight, it is usual that the arm presses directly down and possibly with some slight angled movement to the side. When the arm is in that position and performs that function, the pressure forces the head of the humerus bone against the glenoid labrum. After very many straight arm stroke initiations, the labrum becomes irritated or damaged resulting in *"swimmers' shoulder"*. Once the labrum is injured, reoccurrences of the problem occur more frequently unless there is a corrective technique change; those changes being described here. There is no place in freestyle stroke for straight arms underwater.

Good examples of the repositioning movement after entry to effective propulsion are shown above in the illustrations of Libby Tickett and Inge de Bruijn. Following is Pieter van den Hoogenbond's entry and initiation of the propulsive phase of his left arm. This was taken from a video clip of his 200 m Gold Medal race at the 2000 Sydney Olympic Games. The main feature is the distance in front of the swimmer that propulsion is established (between Frames #12 and #13). For a 50-m swim, he would not reach as far forward and would achieve horizontal propulsion in about one tenth of a second.

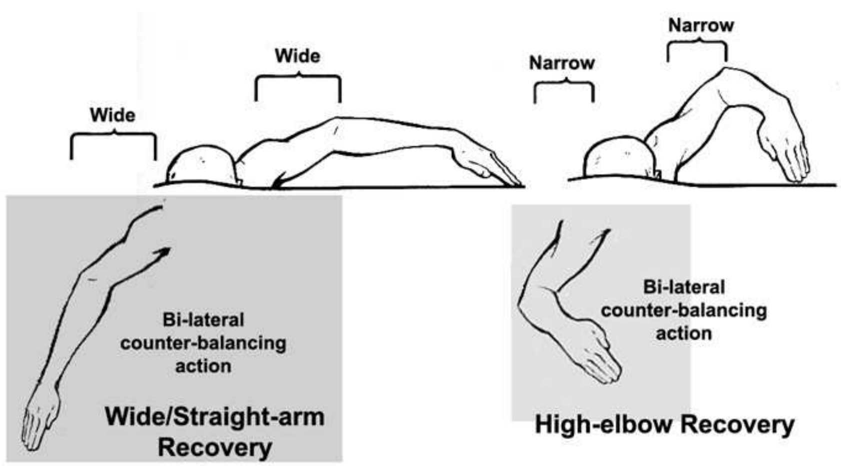


Some sprint swimmers begin to rotate the upper arm and flex the elbow prior to or just as the water is entered. From entry to propulsion should create as little turbulence as possible and be achieved in the shortest time possible.

Arm Recovery

In crawl stroke and backstroke what is performed out of the water with one arm has a modifying effect on the functioning of the other arm underwater. That relationship is governed by the human body's bi-lateral functioning, that is, what is done with one side of the body is also mirrored to a degree on the other side of the body. When coaches modify swimmers' recovery arm actions, swimmer responses are not isolated to the recovering arm. It is dangerous to modify recoveries in the alternate strokes without contemplating or observing what happens to the underwater propulsive action.

The bi-lateral principle when combined with Newton's Third Law explains what happens with recoveries. Simplified illustrations showing the bi-lateral counterbalancing effects involved in two crawl-stroke recoveries are included in the following figure.



The right figure shows an efficient correct recovery (the *high-elbow* recovery).. The left figure illustrates the potential for performance degradation if the recovery arm is modified without first considering and evaluating what happens to the propulsive- and finish-positions of the underwater stroke. The left figure shows that a wide recovery increases the likelihood of a swimmer pulling wide (i.e., having a large lateral force component diminishes the direct propulsive force component). Similarly, the higher a recovery, the depth of the pull is likely to increase. An increase in a vertical force component will reduce the direct propulsive force component of the pull. To minimize those unproductive force components, the recovery arm should be as short as possible (achieved by flexing the elbow as much as possible) and moved along a line in the direction of the intended propulsion.

Throughout the history of crawl-stroke swimming, the emergence of wide- and straight-arm recoveries has occurred. At present, it appears that straight-arm recoveries are being emphasized again. Although this article is on 50-m sprinting, the inefficiencies of straight-arm recovery swimming can be clearly seen in the Youtube video of Lotte Friis in the final of the 800 m freestyle race at the London Olympic Games (https://www.youtube.com/watch?v=JHbNKX3VkIM). Friis' pull was deeper and her rate higher than either Katie Ledecky or Rebecca Adlington particularly as the race progressed.

Slowing caused by straight-arm swimming was shown by Ryan Lochte in the final of the 200 IM at the 2015 world championships (http://swimswam.com/watch-ryan-lochte-win-200-im-world-championships). In the last five meters of the freestyle leg he changed his stroke to straight arm and slowed markedly in comparison to the second place-getter, Thiago Pereira of Brazil. A further example has been Nathan Adrian's change of stroke in the final 20+ m of his 100-m races. At the 2014 Pan-Pacs, the absence of benefits from a wheeling straight-arm stroke when compared to the winner and third-place getters of the race was obvious (https://www.youtube.com/ watch?v=-MVzzkLg-bk). In the latter part of 2015 it is difficult determine if Nathan Adrian persists with this inadvisable straight-arm employment.

> *The increased lateral/vertical forces associated with those recoveries causes the underwater propulsive forces to be modified by being wider/deeper, that is, they are further from the mid-line and direct line of progression and require extra unnecessary counterbalancing actions to keep the swimmer tracking directly down the lane. If wide/straight-arm recoveries are swept wide, the amount of body-roll exhibited will be reduced. That would result in a loss of potential propulsive power. When a straight-arm recovery has height emphasized as well, the pull path is not so wide but deeper than would be in an efficient pull. Counterbalancing actions to negate the vertical component of the underwater arm-action would have to be performed. The energy for those added actions would cause a swimmer to fatigue earlier than when an efficient stroke was swum.*
>
> *One of the major reasons for advocating straight-arm recoveries is that the ballistic characteristic that emerges particularly in sprint events is beneficial. It is commonly opined that 1) stroke rates are increased, 2) the water is "attacked" and results in greater propelling forces, and 3) greater efforts are encouraged. One could argue persuasively and at length that assumptions #2 and #3 are false, but that there is some support for the contention of increased rating. The question then becomes: Are the benefits from increased rating greater than the losses of direct propulsive force components and the addition of non-propulsive counterbalancing actions? There has been no research conducted to answer that question but the hypothesis that the benefits from straight-arm recoveries do not outweigh benefits lost by those recoveries can be argued strongly and anecdotally when the performances of swimmers who change to straight-arm swimming are compared to non-straight recovery performances. Additionally, one has to ask further: If straight-arm recoveries are beneficial, why are they not used in 200 m and longer races?*

> *As is typical with actions in a complex machine such as the human body, there is another reaction to wide sweeping recoveries that reduces the efficiency of a swimmer who employs such an inadvisable movement element. As a consequence of the action-reaction relationship with parts of the body's posture, when a wide recovery is executed, further unnecessary movements that result are the hips move to the side of the wide-recovery and the legs move to the opposite side. That results in increased frontal resistance through disruption of streamline, an added requirement of extra movements needed to correct the inefficiencies that have been produced, and a lowering of the swimmer's stroke rate because the extra movement ingredients take more time. When the counterbalancing wide arm-pull is insufficient to fully offset the lateral forces produced by the sweeping recovery, these extra features will be evident* (Rushall, 2013a, pp. 7.2-7.3).

The classic *high-elbow* recovery has advantages for improving crawl-stroke efficiency. Its characteristics are described below.

- The recovery is initiated by the elbow exiting the water first. That action is followed by increased elbow flexion that allows the lower arm to hang almost vertically in a brief but relaxed manner.
- The high-elbow relaxed recovery is moved forward along an almost direct line so that lateral forces are minimized.
- An emphasis on lifting the elbow high in the mid-recovery will enhance the performance of beneficial body-roll.
- The recovery is timed with the propulsive arm action. Recovery initiation occurs as the propelling arm initiation begins; the mid-recovery position where the elbow achieves its highest position is coordinated with the mid-stroke propulsive position; and the entry of the hand occurs as the elbow of the just-finished propulsive arm begins to emerge to initiate its recovery. This timing is that of a balanced stroke (opposition or superposition indexes of coordination) and minimizes any inertial lags in the total cyclic action.
- A flat finger-tips-first hand entry should occur when the arm can stretch no further forward over the water. There is no sliding of the hand forward underwater or hand-entry thumb first. Those unnecessary actions increase resistance and/or require added actions that are unnecessary.
- The entry is made in front of the shoulder or wider. [Less flexible swimmers will enter wider than the shoulder.]

Ideally, the crawl-stroke recovery should be consequential to the underwater propulsive movement pattern. At no time should a recovery be coached unless the underwater action is considered at the same time. When in doubt, a coach should concentrate on the propulsive characteristics of a swimmer's stroke and ignore the recovery unless it is an unnatural movement pattern, such as a straight-arm.

The following features are a summary of the above and should serve as teaching points, when appropriate, for developing a correct crawl-stroke recovery.

- Initiate by first lifting the elbow out of the water.
- Recover forward along a direct line.
- Emphasize an elbow-lift in mid-recovery.
- Time the recovery with the propulsive arm's action.
- Enter fully forward, flat hand, finger tips first, in front of or wider than the shoulder.

Kicking

A full description of the biomechanics and use of kicking is contained in Rushall (2013a), Technique Microcycle 8.

Kicking is perhaps the least understood and most inappropriately stressed element in competitive swimming. The tenacity with which the fictitious properties of kicking are retained and promoted is a remarkable testimony to the ease of retaining beliefs as opposed to altering those beliefs in the face of contrary evidence. Coaches who emphasize kicking, the effort/size of kicking, and have swimmers train with a lot of board-kicking do not understand free-swimming freestyle kicking. Below are some of the reasons why kicking is not propulsive but in one sense does facilitate propulsion derived from the arms (Brooks, Lance, & Sawhill, 2000; Deschodt, 1999).

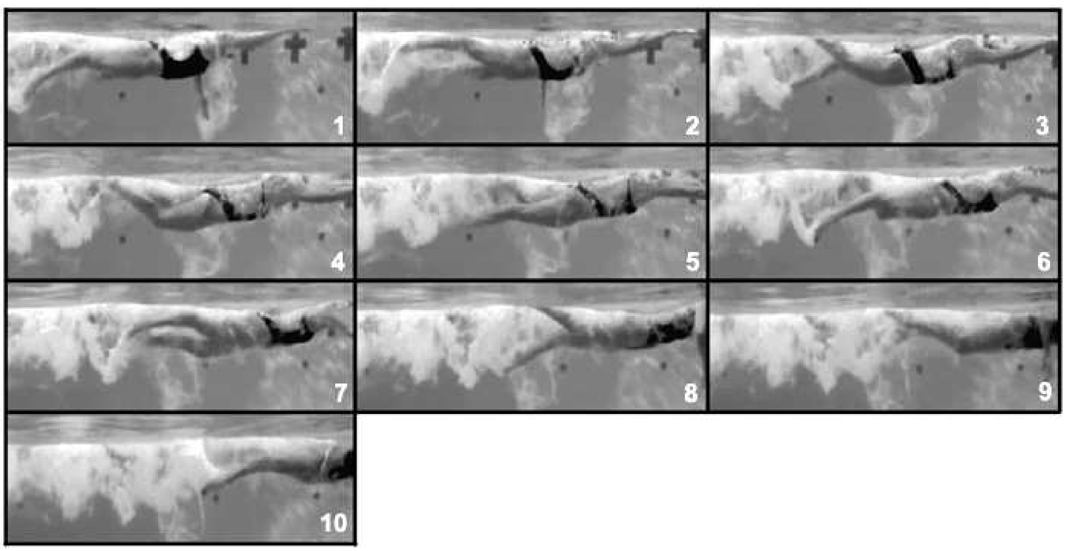
- The foot, ankle, and lower leg never achieve a position where positive propulsive force in the intended direction of swimming is achieved.
- When the kick is too big, resistance is increased greatly particularly if one or both feet break the surface and/or the depth of the kick is below the streamline of the body.

Since kicking in free-swimming is not propulsive, there are a number of important roles of crawl-stroke kicking:

- Small vertical forces have to be created to raise the body and legs to a streamlined position. When the *Centers of Buoyancy* and *Mass (Gravity)* are far apart, in a floating position the legs sink until both centers are aligned vertically (Rushall, 2013a, p. 8.1). Some of the vertical forces created by kicking raise the body and legs to reduce frontal resistance.
- If the swimmer employs a head-up position, the Newtonian reaction is for the hips and legs to sink slightly and break streamline. Some of the vertical force component is used to sustain a streamlined body and legs despite the head-up position.
- The arms entering the water and changing to a propulsive position create a vertical force component, which if not counterbalanced would cause the shoulders and head to rise and fall increasing the amount of active drag resistance. A crawl-stroke kick at a minimum should create a force that matches the vertical forces at entry and exit of each arm. That will assist in maintaining streamline.
- If a swimmer is encouraged to really work the legs in the kick so that a big kick ensues, the excessive vertical forces from the kicking have to be counterbalanced. That usually forces the arm stroke from the entry to employ a more forceful downward stroke to a depth that satisfies the counterbalancing role. An excessive kick in free-swimming, often termed a *kick-dominant stroke*, is inefficient for a number of reasons:
    - At the height of the kick above the body streamline, drag resistance is increased much more than any perceived propulsion that might occur.
    - At the depth of the kick, the drag resistance is increased to the extent that it works more like a sea-anchor than anything streamlined, efficient, or assistive.
    - If the arms do not supply enough extra vertical force component to counterbalance the excessive amount created by an exaggerated kick, then one leg on the upsweep has to be forceful to add a counterbalancing force to offset the excessive downward force of the other leg. This extra work is needed but is unproductive and fatiguing.

- If a swimmer attempts to counterbalance the excessive vertical force components of the kick with the arm action, the change in propulsive movement pattern increases inefficiency usually by fostering a deeper pulling pattern, often a delay in repositioning to commence direct propulsion (usually it is a straight-arm press downward), and the deeper pattern requires increased forces which are largely in the vertical plane causing the arm-stroke to go down, be long with little elbow flexion, and once at maximum depth begin sliding up to time the arm exit correctly.
- If the longer, straighter pulling arm moves to the side of the center line of the body in the intended direction of motion, the some kicks in a six-beat kick occur to create a moment of lateral force to counterbalance the moment created by the arm being to the side instead of being partly under the swimmer. Often, the knee of the leg that is opposite the offending arm will also create drag by dropping out of streamline in order to add more lateral force to keep the swimmer going straight.[4]

In the series of frames in the collage below showing what happens in a kick-dominated crawl stroke, the details of the right leg are clearer than for the left leg. It seems both legs kicked in a similar manner. The discussion of the kicking action illustrated is from Rushall (2013a, pp. 8.5-8.6). The swimmer illustrated is a female 2012 USA Olympic Games Trials qualifier.



- Frame #1: The right leg kick is at the bottom of its downbeat. In this position the right leg cannot be propulsive. The amount of *"milky"* turbulence[5] on the rear of the foot and ankle shows that considerable resistance has been created by the front of the foot and ankle. The swimmer's posture is flat, suggesting that the power for the right arm would come almost completely from the internal rotator muscles of the shoulder. The left arm is half-way through its sweep and is sliding upward. The depth of its trailing turbulence indicates a stroke with a lot of verticality and less than admirable horizontality. The right

[4] The knee dropping down acts like a crude rudder. In water sports requiring efficient movement through the medium, for example, rowing and sailing, the use of the rudder to correct the movement direction is frowned upon. Although rudders have to be used in unavoidable circumstances, their free use is discouraged. Frequent use of a rudder will significantly slow a boat's progress and is not a feature of exceptional coxswains or helmspersons.

[5] The pressure in milky or turbulent water is less than in undisturbed water. It is difficult to discern what proportion of the turbulence consists of cavitation *"bubbles"* or diffused light from the water's movement.

arm is just entering. The kick does not appear to be functioning in a counterbalancing role. The bottom half of the left leg is above the water surface (it is *"kicking air"*).

- Frame #2: The right leg rises and creates considerable downward vertical force, which would provide no beneficial propulsion. The left leg is halfway through its downward kick. [By acting opposite each other, it is likely that both kicks are counterbalancing their excessive irrelevant force productions.] The entered right arm is suspended near the surface and the left arm has risen further (instead of pushing back to a desirable end-of-stroke position).
- Frame #3: The right leg is positioned to *"kick air"* and the left leg is at the bottom of its downbeat. In this position, the left leg is creating forces that have a notable rearward action and therefore, hinders the swimmer. The back of the right leg has increased the frontal resistance of the swimmer and slow progress. The right arm is still suspended.
- Frame #4: The right leg begins its kick by flexing at the knee and hip. The knee drop disturbs streamline. The right lower leg is breaking the surface and will cause cavitation. Although the leg might be oriented to exert a small horizontal force backward, its effectiveness is greatly reduced because of turbulence in the top ~4-6" of water and cavitation. The right arm has been lowered slightly.
- Frame #5: The right leg extends at the knee placing the foot and lower leg in a position that generates mostly all vertical force and a small retarding horizontal force. The right arm begins to move.
- Frames #6 through #10: The ineffective kicking continues.

From the above set of frames, the following features can be inferred.

i. The excessively deep kicking action is mirrored by an arm action that goes deep and then slides up from the deepest point to exit. Optimal horizontal propulsion is not developed.
ii. The arm waits in a forward position, then does its deep stroke, and is timed with the duration of the kicks. The arm action is restricted to how long it takes for the kicks to be performed and because of its depth suggests that the arm is counterbalancing characteristics of the kick, rather than the other way round. With that interpretation, it is projected that the swimmer will never rise to the heights of more successful arms-dominant swimmers.
iii. Body roll is hardly perceived. It certainly is not performed to the extent justified and described above. This also verifies that excessive kicking restricts the performance of good body roll and arm actions.
iv. The obvious *"hard work"* of the kicks performed by this swimmer results in very little, if any, productive work. Thus, the energy available for propulsion will be reduced by the irrelevant work exhibited in this swimmer's kicking.
v. Hard kicking increases resistance at a much greater rate than any potential propulsion or small fast kicking.
vi. The time after the left arm has exited (Frame #3) to when the right arm begins to be pushed down (Frame #6) is a period where no propulsive forces are generated and would cause the swimmer to negatively accelerate in that inertial lag.

Following is a summary of features that should govern the coaching of kicking in crawl stroke.

i. The general description of crawl-stroke kicking should be to *"kick fast and small"*. The aim of that instruction is to have kicking completed in a short time so that the rate of the arms is not hindered and no preventable inertial lag occurs. The scope of the kick should generally remain within the surface to the bottom of the streamline of the swimmer.
ii. Swimmers should attempt to control kicking effort-levels to match or be slightly less than that exerted by their arm strokes. As the effort-level of the arms decreases as task-distance increases, the effort of kicking should be adjusted accordingly. This concept should result in the legs acting reflexively to the arms and should result in a minimal kicking action [the kick will consist of the forces to counterbalance the arms plus the forces needed to sustain streamline].
iii. All kicking should be splashless. Whether in free-swimming, drills, or board-kicking swimmers should be instructed *"not to kick air"* or make splash. This will avoid useless effort and the complications of transferring force to the water that results from cavitation.
iv. The kicking pattern should be consistent. Anomalies such as cross-over kicking (caused by a reaction to an inappropriate lateral force produced by an arm and/or breathing action) and varied-intensity kicking (one leg kicks harder/more than the other which usually is produced by unbalanced arm-actions) should be corrected.
v. There should be some side-to-side rotation in the kicking pattern that is associated with hip rotation. However, the amount of foot rotation does not appear to be as great as the actual hip rotation.

In summary, the following features should be evident in correct crawl-stroke kicking.

- Kick small and fast. Remain within the streamline.
- The effort of kicking should match the effort of the arm strokes.
- Kick splashless.
- Kick consistently.
- Some side-to-side rotation should occur.

Forbes Carlile wrote the following about crawl-stroke kicking (Personal communication, August 12, 2015):

> *As usual I attempted to observe this at the World Championships* [2015] *but the coverage was more concerned with close-ups of participants and what they did show of underwater was brief.*
>
> *However, there was a chance to see the Italian Paltrinieri and Ledecky in their races and certainly in the 800's and 1500's I observed that the Italian often used a 2-beat kick and at times just trailed his legs, yet his lap times were constant and he obviously did not lose speed when not kicking. Katie Ledecky most often was using a 4-beat kick but at times also reverted to periods of leg trail. Both swimmers were shallow in their kicks and their legs were noticeably streamlined. Of course in the 200 m it was a different story and in the last lap in the longer races from these two swimmers. However, the major thing to me is that they clearly did not slow down significantly when they did not* kick [i.e., kicking crawl-stroke is not propulsive].
>
> *It would appear to be absolutely wrong in the course of the event for coaches to harass their swimmers to use their legs as we have seen American coaches in their meets move*

> *down the side of the pool with their arms simulating the leg kick, signaling their swimmers to use the kick more.*
>
> *So it seems to me that coaches should direct their swimmers only to concentrate on a powerful arm action, as I think you will agree.*

Kicking serves to counterbalance the vertical force components created by the arms and to mask faults, such as when an arm pulls deep and/or wide. The coaching belief that kicking is important because it has propulsive properties is unfounded and impossible. The added belief that kicking on a board is the same as kicking when free-swimming is also false. Kicking does not warrant the exaggerated attention at practices that one commonly sees and hears about in many programs.

This ends the presentation of important features of and factors involved in crawl-stroke sprint technique. Technique instruction is more effective and better presented when it follows a valid design of the order of technique elements (i.e., the *center-to-periphery* and *backward-shaping* principles). Because of factors such as growth and capacity changes it is wise to instruct all surface-swimming technique features as a macrocycle. Once the macrocycle is completed, it should be recommenced. Thus, effective swimming coaching and in particular sprint coaching, is a constant emphasis on technique development (Rushall, 2013a).

Section 3
RACING SKILLS TECHNIQUES

There are movement skills that occur in races which need to be executed properly and honed for consistency. Traditional swimming programs place little importance on these discreet movement activities. Consequently, improving the movement skills of racing other than surface swimming is an important avenue for developing significantly large improvements in 50-m freestyle races. The skills considered below are: i) the dive; ii) the transition from the dive to surface swimming; iii) the approach to the finish; and iv) the finish strokes and wall touch. For short-course 50-m/y events, a more cursory consideration of the turn will comprise i) the approach to the turn; ii) the rotation of the swimmer in the turn; iii) the most explosive drive off the wall possible; and iv) the transition to surface swimming.

The Dive

Most coaches have swimmers execute dives with little instruction as to the appropriate technique. There is no consensus on how and what one teaches in a racing start (Wright *et al.,* 2011). Whatever the dive, the intent of the swimmer should be to spend as little time on the block as possible. Swimmers need to work on the consistency of their lowest reaction time and the coordinated sequence of the movements that will lead to the greatest possible power at the point of final contact with the block's platform. There are three different dives.

1. The relay-start dive has distinct advantages over a race-start dive. A swimmer can anticipate when to leave the block (~.10 seconds after the incoming swimmer has touched and registered the touch on the touchpad). In the anticipatory period, a swimmer can execute actions that will increase the momentum of the swimmer in the dive. Swinging the arms in a full arc, contracting the muscles around important joints to maximize the stretch-reflex phenomenon because there is no *"motionless delay"* before diving, and knowing where competitors are in the race are examples of the differences between relay- and race-starts. McLean *et al.* (2000) and Holthie and McLean (2000) showed that some movements and foot positions on the blocks produced better overall relay starts. Gambrel *et al.* (1991) advocated the step-start over the conventional-start. Kovi, Martens, and Morin (2000) found that flatter starts as opposed to higher trajectories and subsequent steeper entries produced better relay starts. However, in unskilled swimmers the simplest relay-start is preferable to starting with attempts at high-level techniques (Takeda, Takagi, & Tsubakimoto, 2010).
2. The race-start associated with events 200/400 m or longer is different to that of a 50-m race in the way it is practiced by competitors (Wright *et al.,* 2005). Shallower dives were exhibited by 50-m sprinters. That difference could simply reflect movement errors that go uncorrected in the general culture of swimming since effective and correct instruction in racing-dives is rarely entertained in traditional swimming programs (Wright *et al.,* 2011). They found no significant differences between genders. Maximum depths for each body part were all significantly different between 50 and 200/400 events but not between 200 and 400 events. The requirement to be motionless on the blocks in the starting sequence disrupts the optimal use of the stretch-reflex phenomenon associated with muscular actions as well as presenting the challenge for a swimmer to adopt a position that will not hinder ensuing movements. For this discussion, it will be assumed that there is a set of

biomechanical principles that should be followed for 50-m/y events that are different for races of 200 m/y and up.

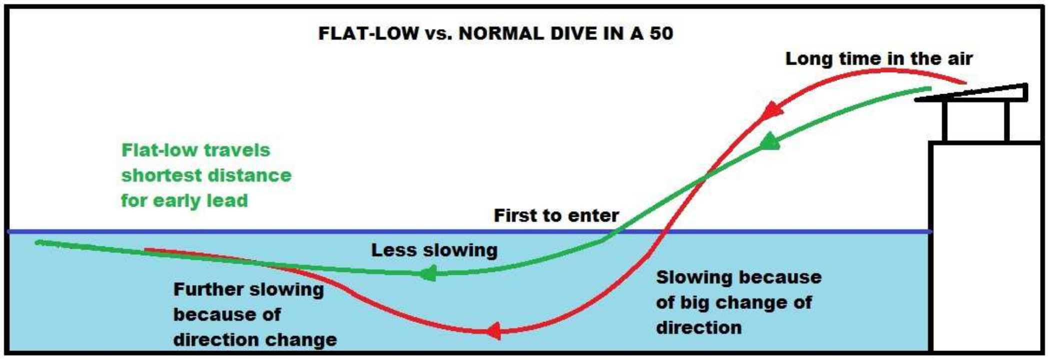
3. Swimmers exhibit different mechanics when starting in events of 200 m/y or longer. From this writer's perspective, it is hard to reconcile actually practicing different mechanics for any stationary start no matter what the race distance. If the 50-m start produces the fastest time to 15 m, then the advantages gained from that start should occur in all races although the intensity of the surface swimming following the dive and its subsequent transition would be less than that for 50-m events. Until valid reasons and/or research are produced for executing different dives depending on race distance, good coaching would employ the same dive mechanics for all stationary starts.

It is assumed in this paper that a 50-m race should be broken into two phases. The first is performance to the 15-m mark. This should be achieved in the quickest time possible. The second phase is from 15 m to the finish. In that phase, a swimmer would not be able to sustain the same velocity produced initially but with proper training, the distance of maximum velocity would be extended as far as the inherited physical characteristics of the swimmer would allow.

Position on the block. The position on the block should feature the following characteristics.

- Use a track start rather than a traditional grab start (Jeurgens *et al.,* 1999). It was revealed that the track start was significantly lower in vertical impulse, higher in average horizontal force, lower in average vertical force, shorter in time on the blocks, and lower in average vertical velocity.
- Employ the *"back kicker"* on the OSB 11 starting blocks. Biel, Fischer, and Kibele (2010) found that when properly used, there were shorter starting and block times and higher horizontal velocities. The foot should be placed comfortably on the kicker with the back leg in a position that to the swimmer feels like it will produce the most explosive movement possible. As well, Nomura, Takeda, and Takagi (2010) reported the knee angle of the back leg to be best if between 105º and 120º. Swimmers were found to have the back leg flexed too much at ~90º. The new blocks with a steeper platform slope and angled kicker also positioned swimmers further forward than the older starting platforms.
- In an exploratory study, Kaufmann and Street (2011) found the as the angle of the block increased, two of three swimmers' take-off velocity improved.
- Swimmers should hold the side-handles if they are available rather than the front of the start platform. Hinrichs *et al.* (2009) found that starts performed with a side-handle grip technique were characterized by significantly longer propulsion times with faster and more horizontal velocities and greater power than with a front grab.
- De Jesus *et al.* (2013) discovered that the most important aspect of the leg drives was knee extension. The practical implication of that study is that once the start-signal has sounded, the swimmer should focus on straightening as fast as possible the knees and in particular the back-leg knee.

Dive trajectory. The figure below indicates the elements of a mechanically correct 50-m start.



Two lines are represented. The red line exhibits an hypothetical flight path for a dive that elevates off the block. The green line is an hypothetical flat dive where gravity affects the trajectory by causing a vertical deviation to the movement path. It is advocated that the green line is a better path to follow than that which includes an added vertical force component. Distinctive features are presented below.

- A flat dive should aim to produce the greatest horizontal force possible. Although gravity will pull the swimmer downward, the intent of the swimmer should be a trajectory that is directly forward off the block. In contrast, the normal (*red-line*) dive projects the swimmer slightly upward so that the apex of the flight path would position the swimmer higher than the block. Following the elevation, there is a steep decline into the water. The vertical velocity component of the red-line dive will be higher than the flat dive because it involves acceleration due to gravity over a longer vertical distance. Although their research involved a relay start, Kovi, Martens, and Morin's (2000) finding that flatter starts are preferable to those with higher trajectories seems also valid for a stationary dive. Fischer and Kibele (2010a) compared flat and pike dives for two groups, each practicing one of the variants. Both groups improved their starting performance significantly. Take-off angles were changed according to required dive types. The flat-entry group improved the horizontal take-off velocity while no change in that factor was observed for the pike-entry group.
- The time in the air of the two dives differs. A flat dive enters the water sooner than the elevated *(normal)* dive. Time in the air should be short because there is no force that can be created at that time which will propel the swimmer down the pool.
- The angle of entry of a flat dive would be less than that of a normal dive. The steep angle of the normal dive projects the swimmer downward producing a longer time underwater all things being equal.
- Theoretically, a flat-dive associated with early entry into the water and continued forward progression would seem to have an advantage over a steep dive.
- The central aim for USRPT swimmers in the dive should be for them to be first swimmer to enter the water and the entry point should be further down the pool than any other competitor.

The above picture illustrates a number of diving forms for a group of national-level elite swimmers. The swimmer fifth from the bottom has elevated noticeably. The swimmer fourth from the bottom has hyperextended his back. The third swimmer from the bottom has dived flat with a straight posture and has travelled furthest down the pool. The bottom two swimmers have some hip flexion. This is an excellent example of a racing-dive in that the swimmer touches the water first further down the pool than any other swimmer.

At entry, the third swimmer from the bottom has entered the water up to the hips. From those swimmers who can be clearly seen, he is the furthest down the pool. One could also opine that his angle of entry is also the shallowest of the five clearly visible swimmers. The swimmer with the elevated dive has not even entered the water. The swimmer second from the bottom has piked at the hips which increased his angle of entry and shortened the length of his dive. In comparison, the bottom swimmer maintained a body position that is close to being straight and has entered further away from the block than the swimmer in the next lane.

From those pictures, several hypotheses can be proposed. First, a flat dive with a straight body has the swimmer further away from the block and entering earlier than any other form of dive. Second, bodily actions in the air (e.g., a high dive, a piked dive, a hyperextended back) do not enhance a dive but rather, reduce its effectiveness. Third, and somewhat allied to the first hypothesis, a spear-like dive off the block is most effective because an athlete will cover more horizontal distance than any of the more complicated/inefficient dive forms.

There are other features of dives that have caused swimmers to be *slow* off the blocks. When the starter gives the command *"take your marks"* some swimmers pull down with their arms making their already cramped position more cramped which will impede their response time and development of velocity off the block. Others pull down and rock back onto their back leg or just rock as far back as possible. The impact of those deficiencies is that they increase the distance over which a swimmer must travel in a race. Where those actions originated is not known but they would not have been devised by someone knowledgeable in biomechanics or the functioning of skeletal muscles.

A group of female college swimmers practicing starts were filmed by this writer. In the following collage of pictures, different starting forms were evident. One advantageous form stood out above the others.

Of particular interest are the four swimmers from the bottom. At the *take your marks* command (picture #1), the bottom swimmer adopts a vertical stance. The second swimmer pulls down on the block and increases the cramped nature of her position. The third swimmer from the bottom rocks back, and the fourth swimmer (indicated with the yellow arrow) leans as far forward as possible holding the block to stop herself from toppling into the water.

Picture #2 is the first movement after the start signal. The fourth swimmer from the bottom has released her hands from the block. No other swimmer has done that. Because she was leaning forward and her hand grip held her back from toppling, upon the hand release she immediately began to move forward. The speed of the hand release determines how long it is before she moves forward.

In picture #3, the bottom swimmer is lunging forward but not using her arms. The second swimmer has risen to a more mechanically sound movement position and released the block. The third swimmer has slowly rocked forward and just released her hands from the block. The originally forward-leaning swimmer is well into her start and perhaps half a body-length ahead of the other women.

In picture #4, the fourth swimmer is well ahead of the others. The swimmer at the bottom is almost flat but has not contributed the mass of her arms to her overall momentum in any meaningful way. The second swimmer is still firmly on the blocks and seemingly heading for an elevated dive. The third swimmer has begun to move forward but is still behind the other swimmers.

Picture #5 has the fourth swimmer entering the water. The first swimmer from the bottom has also progressed forward. The second swimmer has hyperextended her back and elevated. She has severely complicated what should be a relatively simple and direct movement by adding a variety of contortions. The third swimmer still lags behind the other swimmers, the result of rocking backward at the beginning. In the distance beyond the fourth swimmer, another swimmer has elevated remarkably.

THE FORWARD-LEAN TRACK START DIVE
(Olivia Sefton SDSU - 2012)

1. Lean as far forward as possible (as done in a track start). Do not pull back (swimmer closer in black suit).

2. Forward-lean swimmer is first to release from the blocks. Lean-back swimmer is still back.

3. Forward-lean swimmer is reaching and driving off the legs first and is clearly ahead.

4. Forward-lean swimmer is first into full dive.

5. Forward-lean swimmer enters the water first and is clearly a half-body length ahead of the pull-back swimmer.

The lesson from this set of dives is that the simple lean-forward start position provides an initial advantage that is held to water-entry. The other forms of dive are slower.

Arm movements. Another irrelevant and degrading movement that has been introduced is what is done with the arms from the start signal until the water is entered. The science and evidence indicating the best way of moving the arms in a dive has been known for over 50 years. Counsilman (1968, p. 15) covered important mechanical principles found in swimming. The *Transfer of Momentum Principle* was explained by the forward thrust/fling of the arms in a start. The faster the thrust, the greater is the momentum of those parts of the swimmer. When the forward momentum is suddenly stopped, the kinetic energy developed in the action is transferred to the overall momentum of the swimmer. The forward arm thrust needs to be completed before the swimmer loses contact with the block. Thus, the energy to propel the swimmer forward is gained from the sum of the arm thrust and the drive of the legs. If the arms are not used or minimized in the dive, for example the arms are brought forward bent and then straightened to a comfortable position finishing after the swimmer has left the block, the horizontal force component in the start is diminished from what it could be.

More disturbingly, there is a detrimental movement element among even top swimmers. During the leg drive, the arms are thrust backward. The result of that is the forward momentum of the swimmer leaving the blocks is the leg-drive momentum *minus* the momentum of the backward arm-thrust. The pictures of the swimmers to the right are two examples of what not to do in a dive. How much time or race distance is lost with this erroneous action has not been measured but in a 50-m race it is mistake that a swimmer cannot afford.

When a swimmer enters the water, water is displaced as *splash*. Energy is transferred from the swimmer to the water. The greater the size of the splash, the greater the amount of energy lost. The amount of energy remaining in the swimmer will determine a swimmer's velocity underwater. The lower the total energy, the poorer will be the velocity of the swimmer taken into the water. Swimmers should practice spearing into the water to create as little splash as possible (Fischer & Kebele, 2010b). A least-splash dive might not be the flattest dive possible. With practice, swimmers should be instructed to estimate how far down the pool they should enter so that splash is minimal. From then on, swimmers should imagine a hole in the water at the particular distance and attempt to dive in that *hole*.

Summary of features. The following is a summary of the features that should be displayed by a 50-m swimmer when on and leaving the blocks.

- The position of the back kicker should be determined. It should be adjusted so that with the front leg toes over the front edge of the block, the back leg is comfortably positioned on the kicker with the knee at an angle of no less than 105º.
- The hands should be positioned at the side of the block if that is possible. In a worst case scenario, the front edge of the block should be held.
- The swimmer should lean as far forward as possible with most weight on the front leg.
- The eyes should look down with the head in a comfortable position in the hold-position.

- On the start-signal, the hands should be released and the back leg driven by straightening the knee as fast as possible. The hands and arms should be thrust forward as fast as possible and stopped when aimed at where the water-entry will occur. The forward arm-thrust should be completed before the front leg leaves the block.
- The shoulders should be kept low so that the trajectory is horizontal (or even slightly less). Under no circumstances should the dive include any increased elevation.
- As the swimmer's mass shifts forward, the head should be raised briefly to look at the imagined hole that the swimmer will dive through.
- The intention should be to dive flat and shallow.
- Once the direction of the dive has been determined. the head should be held between the upper arms so that the top of the head will contact the water upon entry. The position of the total swimmer should be rigid and spear-like. No in-air movements should occur (e.g., no pike, hyperextended back, head rise, etc.).
- The water entry should be as splashless as possible so that a maximum amount of momentum can be maintained and a minimum of energy lost. It should occur before any other swimmer and be further down the pool than any other competitor.

The overall feature that governs the effectiveness of a racing start is the amount of practice with accurate (timed) feedback (de la Fuente & Arellano, 2010). Not providing sufficient practice to employ the elements of a good start is equivalent to not instructing about those elements. It is interesting that precise times were more effective for influencing swimmers' progress than less precise information such as a coach's qualitative comments.

Transition from the Dive

The transition from the dive constitutes the underwater activity from when the swimmer senses a reduction in velocity after entry into the water until the beginning of surface swimming. The activity that takes place in this phase of a race is distinct from all other underwater activities. Its intent should be to preserve as much of the dive velocity as possible, which differentiates it from simple double-leg kicking.

Angle of entry and slowing due to turning. The theoretical intent of the underwater activity that follows a dive is to maintain as much of the dive velocity as possible. The viscosity of the water will naturally slow the swimmer but added movements can increase the rate of slowing.

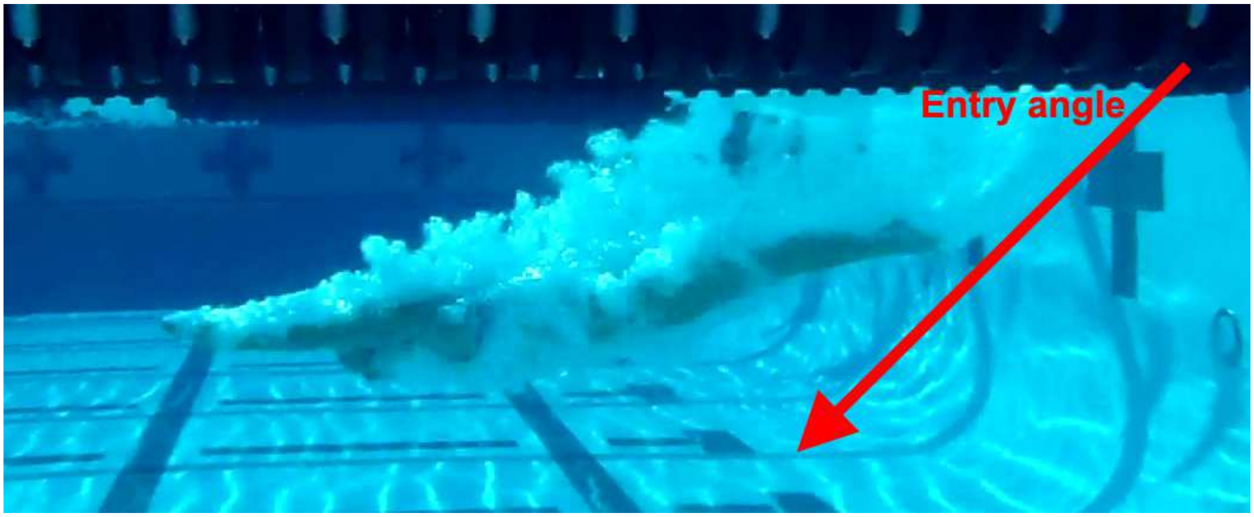
At the start of this section, the diagram of two dive paths depicted the red line as having a steeper angle of entry. In most pools, the depth is insufficient to accommodate a swimmer continuing to progress at that angle, not that such a movement path would be desirable. With a steep entry, the entry angle has to be altered to at least a horizontal path. Usually, the alteration occurs quickly, produces a large amount of turbulence (drag resistance), and the swimmer slows.

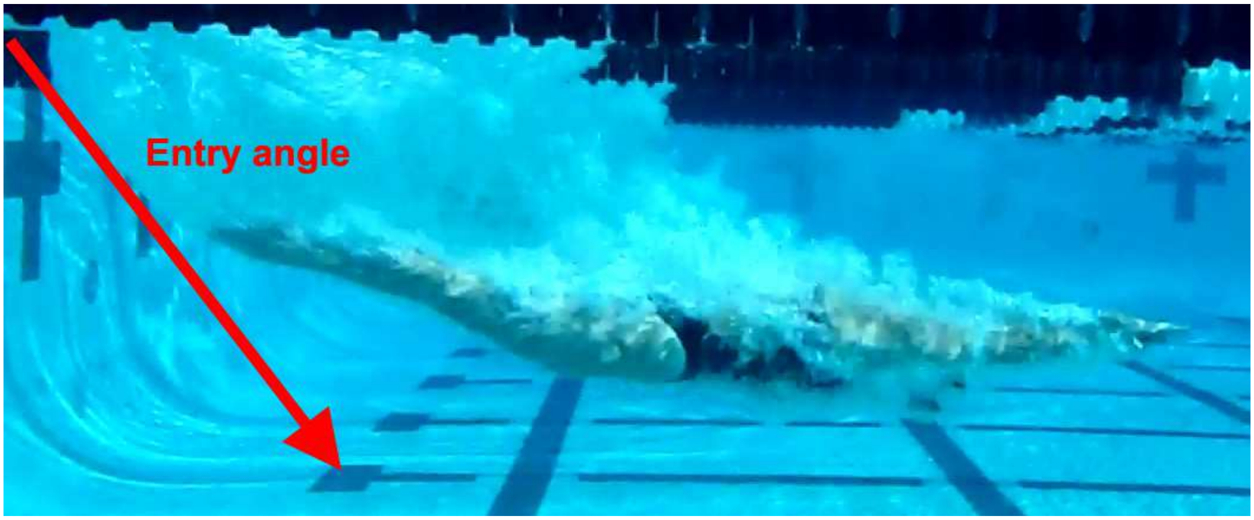
Below are two frames from a video of swimmers diving into a 7-foot deep pool. The angle of entry is measured from the dive until corrective movements begin. These illustrations clearly show the detrimental turbulence formation of a steep entry on horizontal progression.

Both swimmers exhibit similar phenomena associated with a steep dive in a restricted-depth pool.

- The volumes of turbulent water around the swimmers are large. One might expect the turbulence to only follow the top of the swimmer but as can be seen there is considerable turbulence under the swimmers and along their sides. The greater the amount of bubbles and turbulent water dragged along with the swimmer, the greater is the drag/resistance on the swimmer.

- The top swimmer has reoriented her arms to being horizontal whereas the bottom swimmer still has a slight negative angle. Turbulence is underneath the bottom swimmer's arms whereas in the top swimmer turbulence begins at the swimmer's face.





- In order to produce a change of direction, the top swimmer is accomplishing that by altering the position of her arms. Her legs are reasonably straight and her body is not yet horizontal. In contrast, the bottom swimmer has a slight bend in her legs while her body and arms are very close to horizontal. It might be possible that the bent legs reduce a small amount of turbulence because they are not breaking new water. Until it is proven to be incorrect, swimmers should endeavor to curve their body and legs to align with the path of change rather than being rigidly straight.
- It is possible that the top swimmer has taken more time to execute the change of direction which should delay the onset of maximum negative acceleration associated with a direction-change after a dive. That compares to the bottom swimmer who already has

achieved a horizontal position. In theory, a slow adjustment of swimming angle after a dive should produce a slightly smaller degree of deceleration.

The challenge for a 50-m swimmer is to incur as little turbulence as possible once the water has been entered. A shallow dive will require less adjustment of trajectory which should reduce the total drag resistance that occurs in the water. Since a 50-m race, and any race for that matter, requires executing every aspect of the race perfectly, preserving as much of the dive-entry velocity as possible upon entering should be a goal of this part of a race. Kovi, Martens, and Morin (2000) found that males in general dive and enter the water at a flatter angle than females and that low-angled entries produce faster times to six meters than do steeper entries.

Conscientious coaches should take underwater videos of many dives at practice with the intent of observing/discovering how a swimmer should enter the water in order to minimize resistance. It is very likely that too many swimmers dive too steep, which could well be a result of faulty on-the-block and/or in-air movements as were shown in the previous illustrations.

The justifications for and research supporting the angle of entry from a dive seems to support flat (low-angled) entries over steep-angled entries. The ensuing underwater adjustments in the transition phase of a race start seem to be less bothersome with a flat start as opposed to a steep entry.

The shallow vs. deep dilemma. There is equivocal evidence about the depth of underwater swimming.

Jiskoot and Clarys (1988) had males (N = 43) towed in a 200-m tank on the surface and at a depth of 60 cm at speeds ranging from 0.7 to 2.0 meters per second. Resistance increased in the vicinity of 20+% when towing velocity was increased from 1.5 to 1.9 m/s. That amount is far in excess of previously published values of 11%. Resistance was found to be greater when totally submerged than when swimming on the surface. Underwater resistances are due to total frictional resistance plus total eddy resistance while on the surface there is wave resistance, and partial frictional and eddy resistances. Surface swimming was advocated as being better than submerged swimming. Kovi, Maartens, and Morin (2000) and Wright *et al.* (20050 advocated a shallow dive which has to support such a dive being followed by shallow swimming.

Marinho *et al.* (2010) measured the effect of depth on drag during the underwater gliding (double-leg kicking) phase of swimming races. During gliding, a swimmer model's mid-line was placed at different water depths: 0.20 m (just under the surface), 0.50 m, 1.0 m, 1.50 m (mid-pool depth), 2.0 m, 2.50 m, and 2.80 m (bottom of the pool). The coefficient of drag and the hydrodynamic drag force were computed using a steady flow velocity of 1.60 m/s for the different depths run for three seconds in each case. The drag coefficients at each successive depth were 0.67, 0.62, 0.53, 0.44, 0.36, 0.30, 0.28 and the drag forces were 100.20 N, 92.30 N, 80.50 N, 65.40 N, 53.40 N, 44.70 N, and 42.0 N. At considerable depth (1.5 m or more) the retarding drag force is reduced by almost 40%. The deeper a swimmer goes after the dive and turn, the greater is the likelihood of an improved performance because the *"slowing effect"* of the water is much less than at shallow depths. Essentially, this supports the contention that after dives and turns a swimmer should swim deep.

Tor, Pease, and Ball (2015) quantified total drag force as well as the specific contribution of wave drag during the underwater phase of the swimming start. Swimmers were towed at three different depths (surface, 0.5 m, 1.0 m) at four speeds (1.6, 1.9, 2.0, 2.5 m/s). As depth increased and regardless of speed, total drag decreased (-19.7% at 0.5 m and -23.8% at 1.0 m). This phenomenon is largely due to a significant reduction in wave drag when swimmers travel at greater depths. It was recommended that swimmers travel at least 0.5 m below the surface to avoid excessive wave-drag forces.

To answer the conundrum of deep vs., shallow, perhaps other factors should be considered. To swim deep, time and energy will be consumed reaching the depth. If a steep-angle dive is advocated, its benefit will mostly be lost by the swimmer having to change direction abruptly near the maximum intended depth. If some underwater kicks are taken to get to a planned depth (e.g., 2 meters) extra energy will be used to combat the hydrostatic force of floating. Once the desirable depth is achieved, if considerable kicking will be performed it will need to be done with the swimmer's streamline tilted to -4º (Pease & Vennell, 2010). When finswimming and striving to maintain a constant depth, swimmers incline their overall streamline at a negative angle. The picture to the right shows the inclined position of the noted finswimmer, Anders Larsson.

Since the maximum distance from the start wall that a swimmer can remain submerged is 15 m, the considerations above need to be contemplated. The overall benefit of getting to a beneficial depth (e.g., two meters) has to be weighed against the cost of getting to the depth, the changes in swimming direction to get down and rise up before 15 m, and the efficiency of the double-leg kicking that would be used for propulsion. The diagram at the beginning of this section shows the red line (deep-swimming) has to cover much more distance than a shallow-dive shallow-swimming strategy would take. How to arrive at a decision that benefits a performer is considered at the end of this subtopic.

The character of double-leg kicking. High-rate double-leg kicks should begin as soon as the swimmer senses slowing (approximately 0.8-1.0 seconds after the feet have entered the water). Considerable research on how to double-leg kick effectively has been conducted at the Western Australian Institute of Sport. Basically, they have shown that the fastest progression occurs with small fast kicks of the legs with stationary torso, hips, head, and arms. The movement has very little in common with butterfly stroke kicking although that is often used as an analogy. The striking feature that has been produced is that *"big kicks"* might feel stronger to swimmers, but overall at the extremes create more resistance than propulsion created. There is only a small zone where propulsion from the legs significantly exceeds the resistance their movements create. A rough estimate of the effective zone for double-leg kicking is to keep the kicking arc within the streamline of the swimmer.

There are few models that one can emulate because rarely are progression velocities recorded. One outstanding kicker is Hill Taylor (https://www.youtube.com/watch?v=Vox9KOxC1ZA).

Elipot *et al.* (2010) concluded that the leg actions should be restricted to the hips and below. Houel *et al.* (2010) found that the movement amplitudes and segment timing change in the early stage of kicking after a start. After a stable kicking form is reached, the underwater movement should stress holding the torso (plus head and arms) stable while kicking involves the hips to the ankles. There should be no change in amplitude of the hip or ankle movements throughout the underwater action. The undulation moves through the hips down to the ankles. Apparently, the pressure of the water moves the feet into the most natural position possible to develop final propulsion (much like a set of flippers).

The ability to generate small and fast kicks is dependent upon the legs providing the main actions. In many swimmers it will be difficult to hold the hips perfectly still. The reason behind not exaggerating the hip movements is that such movements would move a lot of water; the energy for the unnecessary fluid movement coming from the swimmer. To minimize the use of the hips, coaches should only coach what to do with the legs, concentrating on rate of kicking rather than size. It often is beneficial to instruct swimmers to limit the size of their kicks so that they can improve their kick rate. If there is any vertical movement in the arms, head, or upper trunk at all, the amplitude of kicking should be made smaller until the unwanted movements in the forward structure of the swimmer cease.

Surfacing. Rising to the surface should follow a smooth and gradual path. The swimmer should time surfacing with when the velocity from the dive and kicking declines and reaches free-swimming velocity. If a swimmer is fast enough, double-leg kicking should continue as long as possible and not end prematurely. The alternate-leg kicking associated with crawl stroke should begin when the deep arm starts its pulling action. For shallow-entry and kicking, the hydrostatic vertical pressure of the water usually is sufficient to rapidly bring the swimmer to the surface to start swimming.

Just prior to reaching the surface, the swimmer should roll to the preferred side (about 45º) so that the first arm pull will be the deepest arm (Larsen & Hinrichs, 2005). If a pull was made from a flat-shoulders position, it would be weak because only the internal rotators of the shoulder-joint could be used to power the pull. The power and explosiveness of the first few strokes should be sufficient to have the swimmer reach the 15-m mark in the least possible time. Those strokes set the tempo and effort level for most of the remaining race. Swimmers should be reminded that a 50-m race is actually two races: i) to the 15-m mark, and ii) to the 50-m wall.

Determining how many double-leg kicks should occur. What needs to be determined is how many kicks or how long does the swimmer stay underwater before commencing surface swimming. If underwater double-leg kicking velocity does not match surface swimming velocity, it is in a swimmer's best interests to perform as few kicks as possible and to quickly get about surface swimming where the velocity travelled will be greatest. Some practical tests need to be conducted comparing the velocity of kicking with that of surface swimming.

A series of time-trials over 15 m need to be conducted. A clear 15-m marker has to be established so that the timer can accurately judge when the swimmer passes the mark. Multiple observations and even replications of the experimental trials outlined below on several days are warranted. The aim of the procedure is to discover what mix of kicking and surface swimming facilitates the swimmer arriving at the 15-m mark in the shortest time.

- Timed swims should be conducted with a minimum of four minutes and maximum of six minutes rest between trials.
- Multiple trials are needed and the times for each condition averaged.
- So that only swimming and kicking will be measured, each trial should begin with the wall push-off. The timer/stopwatch should be started when the feet leave the wall, otherwise the starting actions could influence the eventual times.

A suggested testing procedure follows.

1. Push-off on the surface and swim no-breathing crawl stroke through the 15-m mark.
2. Push-off to underwater and double-leg kick through the 15-m mark.
3. Second trial: Push-off to underwater and double-leg kick through the 15-m mark.
4. Second trial: Push-off on the surface and swim no-breathing through the 15-m mark.
5. Third trial: Push-off on the surface and swim no-breathing through the 15-m mark.
6. Third trial: Push-off to underwater and double-leg kick through the 15-m mark.

If kicking is fastest, the transition should be mostly kicking. Swimmers should perform 15-m swims but with a dive. They should experiment with increasing the number of kicks or kicking particular distances until surface swimming commences. To be sure the performances are consistent, the swimmer should perform three trials of all conditions. The fastest average of all the kicking variations should be the structure of the transition to be used in races until the whole experiment is conducted again, particularly after significant technique or racing-skill changes.

If surface swimming is fastest, the transition should involve surface swimming as much as possible. Swimmers should perform 15-m swims with a dive. Their aim should be to swim as many strokes as possible. However, even with a shallow dive, a few kicks will be needed. The swimmer should be aware that if the change from kicking to swimming is too abrupt, slowing will likely occur. The swimmer's intent should be to kick and sustain as much of the dive velocity as possible. When slowing is sensed, the swimmer should be on the surface ready to complete the remainder of the 15 m with surface strokes. Repeated trials varying the length of time before surface swimming starts are necessary to arrive at a reliable decision of what is the best combination of kicking and surface swimming so that the swimmer will record the fastest time possible for 15 m.

Few coaches perform experiments of the type above. They are conducted to discover the fastest strategy for arriving at the 15-m mark. Essentially, the testing defines an individual's dive-transition structure. Since 50-m races need to be perfect, every change in a swimmer's technique or strategy needs to be tested to see if there are benefits for racing. In is unsatisfactory for a coach to assume that a change in a 50-m swimmer's training will be valuable. It is possible that some changes could be detrimental. One might never know that unless repeated time-trials over shorter-than-race distances are conducted with complete recovery between trials. In all such testing, performances under the conditions and features experimented with need to be recorded for future reference and comparisons.

Surface Swimming to the Approach to the Finish

The body of a 50-m race that involves surface swimming without breathing has an oxygen cost. Fernandes *et al.* (2013) estimated the oxygen demands of the event. They found the demand to be substantial for the first 12-15 seconds of a ~31.0 second swim but then demand accelerated to a much greater degree in the remainder of the swim. That would have an effect on what is performed at stages in a race.

The first lower-oxygen-use phase involves the transition segment of the race and perhaps some strokes to cover close to 20 m of the total event. In that period of surface swimming, the race to 15 m will have ended and the remainder of the race warrants a slightly different intent. One can only make recommendations about what to concentrate on in terms of stroke length and rate. In this writer's opinion, the rest of the race which is set up before maximum oxygen utilization occurs (i.e., as depicted by Fernandes *et al.*), the stroke rate should be the highest possible but without compromising maximum stroke length. Kennedy *et al.* (1990) found that beyond an individual's optimum rate, stroke length is shortened. What separates superior swimmers from lesser performers is an ability to hold longer stroke lengths for longer periods of time. The swimmer should attempt that until the finish is approached.

One successful method for maintaining surface-swimming velocity and stroke impulse is to concentrate on the acceleration and direction of the underwater pull. In doing that, the error of slowing other parts of the stroke, such as the time the arm is held in front of the swimmer or a slightly slower initial action, should not be made because the slowing makes other parts of the stroke feel faster although their velocity might not have changed at all. Not only is propulsive acceleration important, but the impulse created should be horizontal rather than become somewhat circular as happens with a definite deep part of the pull with the arms flexed less than is desirable. Many sprinters focus on thrashing the arms around without emphasizing the propulsive forces created. It is what happens underwater that determines swimming performances, not cosmetic above-the-surface actions. Swimmers should be timed over a set distance to determine if an increase in underwater acceleration and a more precise horizontal push result in a faster surface-swimming velocity.

As fatigue accrues there will be a strong tendency to lessen the intensity of the strokes being taken. With appropriate psychological manipulations, such as *Intensification* (Rushall, 2008), exercise intensity can be maintained longer than when not used. Johnson (1991) showed that was possible in swimming.

Stroke rates are particularly individual and that individuality must be respected by the coach to optimize a swimmer's performance (Chollet *et al.,* 1997; Swaine & Riley, 1983).

Approach to the Finish

In the region of 10 m from the finish, surface stroking should change. At this time, most swimmers will be very stressed by the need for oxygen if they have not taken a breath during the race. However, that level of stress is not peak stress because there are other life-experiences that are considerably more stressful (e.g., fighting for survival in the last throes of drowning). It then becomes a challenge for swimmers to be very tough on themselves and hold to a race-plan that will finish in a few seconds. At the distance from the finish that has been determined, the following are advised.

- Increase the stroke rate markedly primarily through underwater work and not in the recovery. It has been observed that stroke length is maximized at a particular rate. When that rate is exceeded, stroke length is decreased. However, the combination of the increased rate and the slight shortening of stroke length, when done correctly should still result in a velocity increase.
- The shoulders and head should be pushed further underwater so that water travels over the top of them. That reduces the negative impact of the head's bow-wave and the shoulder-wave.
- No breath should be taken.
- Each stroke should be executed with an exaggerated horizontal propulsive technique.

The Finish

The wall touch should be the fastest most aggressive movement in the 50-m race. Boxers are able to learn to dramatically increase the velocity of an arm punch. Swimmers should be able to do that too. There are just too many Olympic Gold Medals[6] lost by one one-hundredth of a second to not be concerned about improving touch speed. The examples provided in the footnote justify focusing on every element experienced in training for the 50-m event, before a 50-m race, and during a 50-m race. They must be executed perfectly. Any opportunity to improve 2/100ths of a second could be the difference between winning and losing an Olympic Gold medal or any medal.

The touch should be at the surface or slightly below, that is at the point which is the shortest distance from the swimmer to the touch pad. Touching deep or high requires the arm to stretch a greater distance than directly at the wall. The touch should be with the hand and fingers extended fully with wrist flexion and finger hyperextension to occur only after the touch as an injury-prevention action.

A judgment of the distance to the wall should be made on the last stroke.

- If more than half a stroke is required, a shortened blast-stroke (as quick as possible) should be completed.
- If less than half a stroke is required, the swimmer should alternate-kick at the wall with heightened streamlining and increased kicking frequency. An exaggerated reach for the wall should involve burying the head, rolling the shoulders and hips to allow the reaching arm added length through shoulder tilt and extension, and trail the other arm in contact with the body and upper thigh.
- The last stroke before the exaggerated reach should be the most powerful possible.

One way of demonstrating to swimmers how to extend fully when reaching for the wall is to have swimmers get close to and face a wall. Then have them reach as far up the wall as possible with one hand even to the point of standing on one leg' toes. Instruct the swimmers to use every bit of energy available to reach for even one more centimeter. Have them repeat this movement alternating hands with each successive trial being faster relative to the previous trial. The point behind this exercise is to have swimmers experience the position and stretch that is needed and more importantly understand that the last bit of effort in a race is used to stretch at the wall as fast as possible and possibly touch-out some other swimmers for a better placing in the event.

The finish approach and touch should be practiced very frequently so that the decision-making of whether to or not take an extra stroke, the exaggerated power in the last stroke, and the longest reach/lunge are extremely well-learned for both arms, not just a favored arm.

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[6] Some swimmers that have lost Olympic Gold Medals by 1/100th of a second are Dara Torres in the 50-m FS race in Beijing (2008); Milorad Cavic in the 100-m BF race at the Beijing Games; Duje Draganja in the 50-m FS race in Athens (2004); Limin Liu in the 100-m BF at the 1996 Atlanta Games; Gary Hall Jr. and Anthony Ervin tied for first in the 50-m FS race at the 2000 Sydney Olympic Games; Matthew Biondi in the 100-m BF at the 1988 Seoul Games; and Karoly Guttler in the 100-m BS also in Seoul.

The Turn for a Short-course 50-m/y Race

The Approach

A certain distance from the wall should be designated as the *"turn zone"*. Commonly, that is where the lane lines change to red to signal 5-m to the wall. Most of the content for this subtopic is taken from Rushall (2011).

- One breath could be taken as the turn-zone is entered. It should signal the swimmer to increase all movement speeds.
- The stroke rate should be increased. This should be achieved by increasing the speed of movements rather than by using stronger or greater-effort movements.
- A judgment of the distance to the wall should be made.
    - If more than half a stroke is required, a shortened *"blast stroke"* (as quick as possible) should be completed.
    - If less than half a stroke is required, the swimmer should alternate-kick at the wall with heightened streamlining and increased kicking frequency. An exaggerated reach forward should involve burying the head, rolling the shoulders and hips to allow the reaching arm added length through shoulder tilt and extension, and trail the other arm in contact with the body and upper thigh.

The Turn

- To initiate the turn, the lead arm should be driven forward and down with heightened effort.
- The next action should have the head and shoulders following the lead arm going down and there should be flexion at the neck and hips. The hips should flex violently and sufficiently to bring the thighs into contact with the chest. Once that position is practiced, the legs should be flexed at the knees to create a tight ball. The swimmer should pull really hard with the deep lead arm to facilitate rotation, not swimming forward. There needs to be some lateral rotation in the turn and so the head should flex forward and be tucked somewhat under one armpit – that which is on the lead arm's side. That orientation to the side should produce a quarter-rotation in the turn so that the feet land on the wall with the toes pointing at right angles relative to the vertical.
- The knees should be snapped onto chest with the legs contributing to the swimmer forming the smallest possible ball. The tightness of that *"ball"* will govern the rotational velocity in the turn. Attaining the *"smallest-ball"* position is not easy and might need to be practiced as a drill. An adequate position that is close to the best position possible is demonstrated when a swimmer can swim forward on the surface and suddenly perform a forward somersault. When that position is held and two rotations can be completed without any assistive movements, the swimmer is very close to a *tight-tuck* turn position.
- The swimmer should not wait (i.e., lose time) for the feet to be planted on the wall. The legs should be extended when the swimmer estimates the feet can be *"stomped"* onto the wall to develop the most powerful drive off the wall. However, the timing to achieve this is particularly difficult to perform consistently, but can be achieved with sufficient focused practice. If the knee angle is outside the desirable range (too much or too little), the swimmer should still attempt to contact the wall with the feet in the best position (i.e., pointing to the side).

- The feet should land on the wall with the knees bent 105°-120° and the balls of the feet taking most of the weight. Where they land should accommodate a direct slightly-downward thrust off the wall so that a good kicking swimmer will be near two meters below the surface during the ensuing kicks (if they are good at kicking).
- Deep breakouts are justified to avoid the upper turbulent water that is a residual from swimming into the wall in the previous lap. The swimmer should be deep enough to kick in relatively undisturbed water. Two meters for underwater double-leg kicking results in a major advantage for a swimmer over shallower competitors (Marinho, Barbosa, *et al.,* 2010; Marinho, Ribeiro, *et al.,* 2010). However, if the swimmer is a poor kicker, the direction of the push-off should be upward so that only a few kicks need be made before surface-swimming commences.
- Explode off the wall with the body oriented to the side. The degree of explosion is the single most important factor that governs the performance of the turn and break-out (Puel *et al.,* 2010; Zamparo *et al.,* 2010). The glide following a good/maximal explosive leg-drive should last for ~.8 seconds and should emphasize streamline (Wada *et al.,* 2010) before double-leg kicking commences.
- In the glide, the swimmer should streamline with the head down and upper arms pressing on both sides of the head.

The Transition/Break-out

- During the early very quick double-leg kicks, the swimmer should turn gradually to a flat position. [There is no advantage and only disadvantages to kicking on the side.]
- The aim of the kicking should be to maintain as long as possible the velocity derived from the explosion off the wall.
- The highest number of very quick double-leg kicks should be performed. Such double-leg kicking when performed with moderate or greater skill can be faster than surface swimming (Zamparo *et al.,* 2010). If the swimmer believes he/she is still going fast, more kicks should be executed and the length of time underwater extended, even if holding one's breath requires more effort and discomfort is increased. The opportunity to use the full 15 meters of allowable underwater swimming should be taken at every opportunity by proficient kickers. Poor kickers would do fewer kicks.
- The activities and decisions made for the transition after the dive apply to double-leg kicking after a turn.
- As surfacing begins, the swimmer should rotate partly to the side (45º), and one stroke should be taken with the deep arm to pull the swimmer through the last part of the *"total turn"* to the surface. [Thus, there will be no breathing on this preliminary stroke.]
- There should be no breath taken on the first recovery stroke.
- The first two strokes should be emphasized and explosive. They will set the stage for the remainder of the pool length.

Racing Skills Practice

Each racing skill is as important as the technique of surface swimming. At practice sessions for 50-m swimming, time should be allotted to practicing one or perhaps two of these skills at a time. Improvements in the performance of racing skills will result in faster overall times in 50-m events. In a two-hour practice, at least 30 minutes being devoted to racing-skill improvements is quite reasonable.

Section 4
PERFORMANCE PSYCHOLOGY

Performance psychology encompasses the physical and mental behaviors that enhance performance. Research has been conducted in elite competitive swimming environments to discover valid and reliable mechanisms that result in improved or predicted levels of performance (Jamieson, Rushall, & Talbot, 1976; Rushall, 1976, 1978). Involving the mental skill of following a script of behaviors that are associated with superior performances is one way of developing a positive approach to competing. In the behavioral approach to psychology that is espoused by this writer, the development of vague concepts supposedly being psychological structures does not occur. In this manual section, activities and thought content are described more in terms of what to do rather than appealing to vague and often unverifiable concepts.

Most of what is related in this section is included in several publications by this writer:

i) The original exposition of behavioral performance psychology describing what was done with the very successful Canadian National Swimming Team from 1975-1978 (Rushall, 1979).
ii) A swimming-specific manual written for young swimmers (Rushall, 1995). [The best resource for swimmers to commence learning useful and necessary mental skills for racing.]
iii) A general detailed manual for mental skills training (Rushall, 1992, 2008) that can be used by swimmers to develop all aspects of performance psychology which apply to swimming training and competitions. It is appropriate for all sports and covers skills for situations in and outside of competitive environments.

Successful swimming begins with the first stroke taken on the first day of practice. The rate of progress depends upon the amount of benefits that transfer from training to competitions. USRPT attempts to guide coaches with a process that increases training transfer to a degree that is not accommodated by common/traditional training. Within a swimming season, successful competing starts well before a competition date. The attention to details and practiced behaviors is an essential component of what should be done from waking on a competition day to starting in races. They need to be learned from repetitious practice. Some psychologists (including this writer) have opined that 50% of competitive success is governed by what happens before a race. A large part of a race result is determined by the beliefs about competitive success held by a performer prior to competing (Noakes, 2012). It is not the intention of this manual section to produce a review of all psychology that could be associated with competitive-swimming success. Suffice it to say that successful competitors need to be high in self-efficacy (i.e., self-confidence), have no doubt as to the exact manner in which a racing-task is prepared for and executed (i.e., detailed pre-race and race strategies), have the ability to focus solely on their own thoughts and actions (i.e., not be distracted by others or events that are beyond their control), and conscientiously apply themselves to the pre-race and race-strategies they have developed. Embedded in those descriptions is the understanding that everything that is experienced and executed at a competition has been practiced. That leads to an underlying requirement for successful performance – *attempt nothing new on a competition day or in a race*. Thus, some parts of practices have to allow swimmers to practice what they will do and think at swim meets.

When a USRPT activity is described, the first element that is required is concentration on some aspect of technique, racing skills, or pre-race and race-strategies. This discussion is limited to appropriate mental activity for 50-m freestyle events. The elements discussed below should be considered when developing pre-race and race strategies. The underlying research of factors that need to be enhanced (e.g., physical arousal, mental control, attentional-narrowing (focus)) and removed (e.g., negative thinking, distractions, irrelevant activities) are discussed elsewhere by this writer (Rushall, 1979). The activities described in this section cover the period before a 50-m race when the swimmer starts *"to get ready"*. The length of time in specific-race preparations varies widely between swimmers and even elite performers. However, the activities that should be performed are common amongst top-performers. For this discussion, it is assumed that the *Race Build-up Strategy/Routine* will take approximately 30 minutes.

The major mental activity that is engaged in to focus thinking is mental imagery (*a.k.a.* mental rehearsal). The following is a brief description of performance enhancement imagery (Rushall, 1991). It is followed by an equally brief description of coping behaviors, an essential part of any plan of action.

Performance Enhancement Imagery

Precompetition cognitive rehearsals of intended physical, mental, and emotional components of performance prepare an athlete to be at a high level of readiness at the onset of a race. This effect becomes increasingly noticeable the higher the competency level of the swimmer. Enhanced skill readiness that results from the mental rehearsals of prepared strategies contributes to increased physical efficiency. Much of what is related below about imagery was included in more detail in Rushall (1991). The following features are modifiers of imagery effectiveness for enhancing physical performance.

- ***Familiarity with the strategy.*** The more established is the strategy, the more accurate and beneficial will be the imagery.
- ***The timing of occurrence.*** Strategy imagery may be most effective when it is interspersed throughout physical activity. It should be the major mental task in the race build-up routine.
- ***Control and vividness of imagery.*** The better the control and vividness of the imagery, the greater will be the enhancing effect.
- ***Orientation.*** Successful athletes report *"internal"* or phenomenological imagery (non-visual, proprioceptive rehearsal; imagery from the athlete's perspective) as contrasted to the *"external"* or third-person imagery of less-successful athletes. External imagery, such as viewing an imaginary movie of oneself, to a large degree does not replicate the exact sensations of swimming. Appropriate imagery is that which uses all senses and manifests them from the swimmer's perspective, that is, what is seen, heard, felt, smelled, and tasted in a performance.

Performance enhancement imagery is a mental skill. It must follow exact dimensions and characteristics, be practiced, and be afforded total concentration without any distractions. This activity is as specific as any physical skill. The target activity should be imagined as a successful performance in the environment in which it will be performed. It should include all the sensory experiences that will occur in the race as well as accompanying thoughts associated with the performance. Any difference between the quality and content of the performance enhancement imagery and the anticipated performance will drastically diminish any benefits from the practice. Performance enhancement imagery should involve what will be thought, acted, and experienced in an impending race.

Performance enhancement imagery is only likely to be effective with athletes who have a high degree of swimming competence. For lesser swimmers, minor enhancements could result from the rehearsal of organizational and tactical features of an impending performance.

There are a number of major factors that need to be considered when structuring performance enhancement imagery for use prior to a 50-m race.

1. ***Rehearse at the intended speed of the performance.*** Slow-motion rehearsals of actions have been shown to elicit neural patterns that are totally different to those which are exhibited when a real-speed physical action is performed or imagined[7]. The advocacy of movement-speed specific imagery as being a prerequisite for effective imagery is supported by both research and the reports of successful athletes. The rate or speed of execution of a performance imagination must be exactly that of the intended race.

2. ***Imagery must be positive and successful.*** Rehearsals of activities which generate negative experiences result in an increased use of physiological resources to produce a performance. On the other hand, positive rehearsals will generate physiological reactions that are most efficient. Errors in performance are reduced when there is a positive direction and atmosphere in rehearsal as opposed to that which occurs under negative conditions. Thus, positive rehearsals produce efficient physiological bases for a successful race, they stimulate the most efficient forms of functioning in skills and technique, and affect the overall self-efficacy of the swimmer for performing. It only makes sense to rehearse positive and successful activities.

   The wording and content of imagery should only focus on successful or desirable performance aspects. For example, in swimming *"not missing the wall"* has negative connotations because the concept *"missing"* is an error and *"not"* is negative. A swimmer can be sensitized to negative events just as easy as they can be to positive events. The statement *"planting the feet quickly on the wall"* focuses the swimmer on performing efficiently and correctly. Thus, the descriptions of what is planned for performance will directly affect the quality of imagery. The content of performance enhancement imagery should only be positive in expression and successful in activities.

3. ***Imagery should be performed from an internal perspective.*** This feature includes all the senses that are stimulated in the action. The major sense that is important for sports performance is kinesthesis (*"feel"*). An internal perspective occurs when an athlete views him/herself from his/her own perceptions (e.g., lane markers rushing by, level of tension in the shoulders, the rhythm of stroking). Its counterpart is an external perspective, that is, the athlete sees him/herself in the same manner as would an external observer. The external viewer perception is that which is normally conjured-up by *"visualization"*, where the athlete imagines watching something like a filmed recording of

[7] Jacobsen (1930) demonstrated that recordings of the action potential from specific muscles were altered during the recall of related movements. The perception or imagining of a motion in a person produces impulses to perform the movement itself. That effect is called the *"Carpenter effect"* (Ulich, 1967). The validation of this phenomenon has been repeated frequently. Bird (1984) quantified EMG activity of imagined activity in experienced athletes representing rowing, swimming, water skiing, and equestrian events. All demonstrated altered EMG activity when instructed to image, see, and feel a practiced skill from their sport. In a basketball player, the EMG profile of an actual foul shot matched the imaged EMG profile. When a downhill skier was instructed to *"think about"* racing, EMG recordings of muscle activity demonstrated increased activations that coincided with actual turns and jumps on the race course (Suinn, 1980).

him/herself. The recall of sensory (internal) experiences from the swimmer's perspective is important for performance enhancement imagery. The extent to which athletes control their imagery and perceive performance as if doing it, has been shown to be directly related to performance outcomes at Olympic Games (Orlick, Partington, & Salmela, 1982).

If the kinesthetic sensations of a movement are experienced to a satisfactory level, then minor movements should occur when doing imagery. Those movements are an indication of the correct intensity of feeling in the imagery.

Internal imagery that captures all the sensations of an intense performance should be accompanied by minor physical actions and alterations in physiology. If those physical movements do not occur then the imagery is not intense enough.

The movement that occurs with the correct intensity of performance enhancement imagery, a feature that is displayed consistently by the world's best athletes, is incompatible with the commonly proposed use of relaxation with imagery. The role of relaxation in imagery has never been fully evaluated although relaxation alone has been shown to have no affect upon performance. Relaxation is not a necessary ingredient for performance enhancement imagery.

True *"relaxation"* is far from an optimal state for competition preparation. Relaxation is incompatible with ideal readiness features that need to occur prior to a maximum competitive effort. Thus, relaxation is not what is needed prior to a contest nor is it part of performance enhancement imagery. What is needed is controlled and vivid imagery along with sufficient activity to control arousal and maintain a warmed-up physiology. Control and vividness are easier to achieve in situations free from distractions. When an athlete has a high degree of physical arousal (a.k.a. *excitedness*), walking enhances the control of imagery.

4. ***Rehearsal repetitions.*** There is no clear direction for how many repetitions of performance imagery should be conducted. There no doubt is an individual preference for how much rehearsal should be done. It is best to allow each athlete to elect the volume and frequency of imagery. Imagery is consistently used by superior athletes as part of training and competition preparations. In the last 24 hours before a contest there is a very marked increase in the frequency and volume of rehearsing. Better performers mentally rehearse impending competitive activities to a greater degree than do lesser performers. As swimmers mature in participation, they learn more to rely on their own wisdom for making decisions about what should and should not be done in their preparations for races.

   The amount of imagery practice should increase as a competition approaches. A very marked increase in the volume of imagery should occur on the day of the competition. Much mental practice just prior to the start of a contest serves as one method for developing a focus of attention on the impending performance.

5. ***Imagine in the performance environment.*** It is necessary for athletes and teams to become familiar with a new contest arena prior to performing. The relevant features, important cues, and possible distractions should be noted. This is possibly the only benefit derived from swimming in warm-ups before a meet begins (Rushall, 2014). A

portion of the true performance time will be spent adapting to the environment rather than performing efficiently. The importance of imagining environmental cues has been emphasized by research that showed performing mental practice while looking at the actual physical setting produces marked performance improvements (Prather, 1973). Before a race and perhaps very close to its start, a swimmer should stand behind the starting block and mentally rehearse the impending performance and effort while looking at where the dive will enter and where each stroke and action that will occur at least in the first 15 m of the race.

Familiarity with the competitive environment will reduce the possibility of disruptive distractions. The inclusion of all features of the competition site in mental imagery will aid in adaptation and habituation to unusual environmental cues.

6. ***Rehearse performance segments in their entirety.*** The majority of research articles concerning mental practice and imagery use single, short-duration activities as their activities (e.g., basketball free-throw, dart throw, sit-up). It is not difficult to imagine such activities in their entirety. However, with longer duration activities such as swimming races, the sequencing of interdependent actions and the integration of units of movement into the total perspective of the intended performance are crucial elements for effective imagery. The rehearsal of a 50-m race should start with mounting the block and then be followed by every segment of race-skills and surface swimming in the order they will occur in the complete event. Imagining a racing start in swimming without the critical actions that follow its completion to initiate actual swimming would also omit a particularly important aspect of a start.

   When sections of an integrated sequence of skills and techniques are practiced out of context, the result is a dissonance of certainty within the total sequence. For example, rehearsing surface swimming without the dive and transition would not capture the flow of propulsive elements that are very important for commencing surface swimming successfully. When one changes from rehearsed to unrehearsed segments of a race, performance disruptions should be expected. The imagination of parts of a 50-m race will not exactly replicate what needs to be performed. Only the whole race is satisfactory for performance enhancement imagery.

   The acceptance of the development of structured and practiced race strategies has led to the scope of mental imagery being expanded to include large sequences of integrated activities. A total 50-m race is a manageable volume of imagery. For longer races, where steady states and repetitious segments occur, partial race-rehearsals can be tolerated. But, in a 50-m event, the experiences of and technical demands on a swimmer constantly evolve. There are no two or more phases of a 50-m race that are the same. It is the smoothness of integration of all parts of the race that typifies superior performers. That smoothness can be practiced both mentally and physically when a total activity is performed.

7. ***The inclusion of strategy mental content.*** Competitive performances no longer consist of physical and biomechanical elements. The content of competition thinking (race strategy) to a large part determines the outcome of a performance. Thus, performance rehearsals must also include the mental behaviors that are to occur. The imagination of mental and physical performance components is a requirement for

effective imagery. The inclusion of mental strategies in imagery will increase the learning of that content and will facilitate recall in the performance once it commences. The thoughts and self-talk that have been prepared for use in a race need to be included in imagery. That requirement makes the imagination task more complex and difficult to learn. However, it must be incorporated as part of the physical-mental link that serves as a major aspect of attentional focus before and during a race. In a race build-up routine, there are three component concentrations.

- An emotional arousal component is appropriate for an enhanced readiness state, that is, sufficient physiological arousal to energize performance. This is particularly important for high-rating explosive races such as a 50-m event.
- A neuromuscular facilitation component is appropriate for preparing to do highly skilled performances by stressing the use of skill-relevant cues and movement patterns. In this sense, a skill performance is *"mapped"* prior to its execution through the use of mental imagery.
- An organizational component will enhance the use of relevant resources that are required in a performance. Factors such as timing, focusing, resource allocation, strategy content, and tactics are influenced by this element. This feature will govern the smoothness of transition from one race element to the next.

The data of research, the experiences of practitioners, and the descriptions of athletes support the above factors as being the essential features of precompetition and non-activity phase imagery. These factors differ markedly to the features which are required for imagery that is used to assist learning. Those differences require a differentiation between learning and performance enhancement imagery. There is no one way of doing mental imagery that will serve every possible purpose in sports.

Summary of performance enhancement imagery.

- Precompetition rehearsals of intended physical, cognitive, and emotional components of performance prepare a swimmer to be at a high level of readiness at the start of a race.
- The more familiar a swimmer is with a task, the more accurate and beneficial will be the neuromuscular facilitation that results from imagery.
- Skill imagery should be interspersed throughout physical activity.
- Skill imagery should be performed when physical activity is not possible.
- Mediocre athletes concentrate on factors other than performance in the precompetition period.
- Mental rehearsal is better served when it is practiced specifically for an event and its constituent skills.
- Inappropriate or distractive imagery diverts the body's capacities and prepares it for irrelevant tasks.
- Performance enhancement imagery is a skill: it needs to be performed consistently, produce replicated motor patterns, and take a constant amount of time.
- Performance enhancement imagery is most effective with advanced or superior level athletes.
- Slow-motion rehearsals of actions elicit neural patterns that are foreign to patterns associated with real-time movements.

- The benefits of movement-speed specific imagery are supported by both research and practitioners.
- Positive imagery produces physiological responses that are more efficient for a particular performance.
- The wording and content of what is imagined is critical: It should focus only on successful or desirable performance aspects.
- Imagery should be performed to experience all the senses in the manner in which they occur during a performance, that is, from an internal perspective.
- The feelings that occur in performance are particularly important and, if imagined correctly, will produce minor movements and physiological responses.
- The best combination of physical activity and imagery is to do the activity at competition intensity during the warm-up period prior to competitions.
- Performance enhancement imagery is only a supplementary procedure to that of specific warm-up activities and should be performed when specific physical activity is not possible.
- *"Relaxation"* is not necessary for effective imagery to be performed. Close to the commencement of a contest it is incompatible with desirable precompetition activities.
- The amount of performance enhancement imagery that should be performed should increase for a number of days prior to an important contest with a marked increase (possibly by an amount as much as five times) the day before or on the day of the competition.
- Performance enhancement imagery is facilitated while looking at the exact place of the contest.
- When sections of a performance sequence are imagined out of context, performance is not enhanced.
- Performance enhancement imagery must include all the thoughts that will be associated with and used during the performance.
- Performance enhancement imagery differs markedly from learning imagery.

The development of performance enhancement imagery skills is not a simple procedure. For it to be executed correctly, and to achieve the maximum effect, a number of mental activities have to be learned. They involve the attainment of acceptable levels of image control and vividness, internal content, sensory recall, and the structuring of performance-specific experiences.

Coping Behaviors

Pre-race and race strategies are detailed plans. The level of detail determines the degree of performance variation. With the best laid plans errors and unanticipated events can still occur. Coping strategies are alternate plans that can replace preferred actions. They can be followed to achieve the same activity outcomes as the preferred activities. Preferred plus coping strategies are better than strategies which have no coping alternatives. They produce better performance output and tolerance for stresses (Andrew, 1968; Meichenbaum & Turk, 1975). Predicting and preparing for problems will produce better tolerance and coping responses in performance (Aderman, Bryant, & Dommelsmith, 1978).

The ability to cope with distractions and errors which may occur in a swimming race is never fully realized. Through a constant learning and adaptive process, swimmers should develop knowledge of and should have experienced the behaviors required to handle the various stressors and distractions which occur in swimming and in particular its competitive situations. The degree of acquaintance with these coping behaviors determines the stage of transition for an athlete from being inexperienced to becoming experienced. All sources of input (e.g., coach, other swimmers, officials, team support personnel, etc.) that can shed light on the circumstances surrounding swimming meets and races should be used when developing strategies.

Coping examples for anxiety and negative thinking. Anxious swimmers generally perform slower times (Burton, 1988). It is important that swimmers approach competitions with confidence and a positive mind-set. Any negative talk is likely to indicate the swimmer has a strong likelihood of performing below expectations. For distance events it is important to *"get up"* for a race to mobilize sufficient energy to maintain a strong pace. However, sprinters must remain controlled with an optimum but very high level of physiological arousal. The mental state of pre-race preparations is more important than the physical state that is attained. It is imperative that swimmers remain mentally controlled during the pre-race period. To be able to cope with on-coming anxiety and negative-thinking statements, swimmers should prepare a series (at least 10) of different self-talk statements that are contrary to problematic mental states. Examples of such statements for *anxiety and negativity* are:

- *You have done the work so here is an opportunity to apply it in an important situation.*
- *The first race is your favorite and the one for which you have trained the best.*
- *It will be exciting to see that you will do better than the race-pace you have used at training.*

Coping content for readiness and arousal.

- The readiness to perform involves physiological arousal and mental activity/content.
- Physiological arousal governs the intensity of effort.
- Mental activity governs the readiness/preparedness to perform.
- There is an optimum level of physiological arousal for a particular set of thoughts to produce a best performance.

The procedure for developing a coping strategy in the context of this manual is two-stage. First, the pre-race and race situations are analyzed and planned in minute detail. Usually, pre-race factors will be more numerous and varied than race factors. For each aspect of the pre-race and race strategies the following features should be determined; what will happen, what could result from the occurrence of each activity or event; how will the events affect each athlete; and what actions are appropriate for all events. For each of the activities that are deemed to be important, whether it be pre-race or race, both a primary and a coping behavior strategy should be developed. Strategies should be constructed in the expression style (the way the athlete talks to him/herself in second person) of the athlete so that it contains the utmost meaning for the individual (Maier, 1972). It should stress the behaviors to be done, the content decision should be primarily the swimmer's (Kanfer & Seidner, 1973), and it should incorporate positive task-oriented content (Barber & Hahn, 1962). After initial strategies are developed, they should be evaluated and modified where necessary after each use so that they are constantly refined and improved (Averill, 1973). Each competitive situation will require some modifications that are unique to that circumstance. A principal source of change will be the technique and race-skill competencies developed through USRPT training. Those improvements should be incorporated into strategies and improved pre-race preparations and race performances expected. Competition planning is a required activity for all serious competitions. It can no longer be neglected or treated in the haphazard fashion that is commonly practiced by traditional coaches and athletes.

The second stage for developing a coping capacity is to practice the strategies. The ability of a swimmer to cope with competitive situations is a developed skill. Coaches can do much to accelerate the learning process to produce this capacity. A planned, gradual introduction of the competition behaviors, performance goals and simulations, and distractions should be instituted with the swimmers having a high degree of probability for success with each successive stage of exposure (Orne, 1965). This means that once a swimmer is successful at coping with one degree of situational difficulty, it should then be increased in its complexity and difficulty. The progressive positive experiences of coping have desirable attitudinal and behavioral outcomes when contrasted with the more common total immersion circumstances of stress introduction, that is swimmers are exposed to serious competitions for the first time with little preparation or schooling (Wolff, Krasnegor, & Farr, 1965). The implication of this fact is that coaches have to plan the development of psychological coping behaviors in great detail and for their implementation to cover an extended period of time. They should occupy as much emphasis in the training program as physical development and skill training. They certainly warrant the time and energy that is required to develop them.

Coping behaviors are determined by prior experiences. There are three forms of experience that can be used to yield practices for producing coping repertoires.

The first form is real experience gained through competing in varied situations. The outcomes of these circumstances have positive and negative effects. It is a popular opinion that real experience is the most desirable form of experience. However, the inability to have control over the learning situations means that there is no deliberate structure to learning nor is there any guarantee that all important stressors will be encountered.

The second form is experience through contrived events. This usually takes the form of simulation of competition events and conditions, the practice of pre-race behaviors, and the over-stress of potential distractions. Some practices or parts of practices should be devoted to competition simulations that go smoothly and at other times present problems for which swimmers can practice coping.

The third form of experience is imagery. This entails the mental rehearsal of various situations and events and the execution of the successful primary and coping behaviors associated with them. These experiences should always have positive outcomes. Swimmers can practice the imagery as often as they wish.

Pre-race and race strategies should comprise three sets of planning. The primary or preferred behaviors are those that are most desirable to a swimmer's way of thinking. For each primary behavior there should be an expected outcome (e.g., to feel loose, develop focus, be positive, etc.). For each primary behavior there should be an alternate coping behavior that should yield the same outcome. In the competitive circumstances of swimming, the ability to perform primary behaviors successfully (i.e., they yield the planned outcome/s) should be of a high probability. However, through successful practice experiences, the coping behaviors achieving the same outcome should have been experienced a number of times. This author recommends three times as much practice on primary behaviors as coping behaviors. After much practice and a considerable number of meets (the number depends upon the individual) pre-race and race-strategies should be so refined and developed that their compliant execution develops a high degree of confidence in the swimmer for performing a successful race.

Race Build-up Strategy Content

Considerable research has shown that the effects of an in-pool *"warm-up"* are lost within 20 minutes of cessation (Rushall, 2014). It has been reported that there is no difference between in-pool and dry-land warm-ups (Romney & Nethery, 1993). Even at World Championships, the marshalling and sequestration of competitors, pre-race introductions, and TV requirements have extended out-of-pool time to such a level that in-pool warm-up effects are lost. Many age-group meets provide insufficient space to perform pool-work that will transfer benefits to a swimmer that will alter the response to a race. It is advisable to have at least one warm-up that does not involve in-pool work and another that does. It is likely that the former will be used more than the latter.

Build-up Strategy Components

The race build-up strategy/routine should be designed to peak the readiness state with the start of the 50-m race. The following are recommended activities and the order in which they might be enacted for inclusion in this *peaking strategy*.

Comfortable stretching. Perform dynamic (total body) exercises and avoid static stretching where an extreme position is held for some time (i.e., 20-30 seconds). There should be no assistance from a trainer, coach, swimmer, or other individual to stretch to a range of movement that will not occur in a race. Extreme static stretching depletes the elastic properties of the muscle structures causing intended fast movements to be slower than if no static stretching had occurred (Rushall, 2009).

The exercises should be familiar to the swimmer. No unusual exercises used by another swimmer should be copied. If the range of movement is extreme, the lack of familiarity with the exercise will result in delayed onset of muscle soreness which will affect other races.

The purpose behind every exercise should be to achieve a particular feeling and moderate movement range. In the practices devoted to planning and familiarizing the swimmer with the build-up routine, the swimmer should be able to recognize the feeling and movement range that is desired. It is important that the preparation for a race always follows a path of achieving planned progressive physical and mental states.

The outcome of pre-race stretching should be good feelings and a ready-to-race attitude. Being the first activity in the build-up routine, it should signal to the swimmer that a serious mental state has been entered and that attention to details and self-control of all activities which follow are executed exactly as intended.

Keep active. Mild levels of activities should be performed throughout the race build-up routine. Directed activity is incompatible with the development of race-anxiety. It assists the swimmer to focus on the impending important task. No amount of sub-maximal activity (e.g., dynamic stretching, walking) will tire-out a well-nourished fully-fit swimmer.

Do not be distracted. Distractions take swimmers away from the focus of building readiness for a race. Focus on following a prepared script of activities leads to internal self-control, an important variable for successful competing. Swimmers should make a conscious effort to not be distracted.

Isolate from others. What others do and say is beyond the control of a focused swimmer. Some swimmers alleviate their *pre-race anxiety* by talking to other swimmers. Their prattle has the potential to distract a swimmer who is attempting to maintain and build focus. Simply avoiding groups of swimmers or walking away from a swimmer who seems to be coming their way are physical actions that can prevent distractions and possibly upsetting circumstances.

Concentrate on the task. The purpose of the race build-up strategy is to gradually heighten a swimmer's focus on the impending task/race. It is appropriate to only engage in purposeful task-relevant activities. Everything in a prepared race build-up routine/strategy should have a purpose. If something is planned that will not help the preparedness for or performance of a race it should be removed from the strategy.

Performance enhancement imagery. The major cognitive activity of the race build-up routine is performance enhancement imagery. It should be performed exactly as described at the start of this section. The rehearsal of a race is analogous to an actor rehearsing lines for a show. It should include the remainder of the build-up routine as well as the race. It is common practice to begin the build-up routine with fully focused (i.e., non-distracted) rehearsal of the pre-race and race strategies. The detail applied to pre-race activities should be as much as that given to a race. [Since a 50-m race has a different level of thought detail when compared to other events, it is only for that sprint that the pre-race and race detail are somewhat similar.] In particular, the activities planned for closer to the race should be rehearsed in greater detail than those at the outset of the build-up routine. Performance enhancement imagery should be performed throughout the build-up, with the amount occurring being that which satisfies the swimmer. This imagery should increase as the start approaches and should always be accompanied by movement.[8]

Gradually neglect distant segments. At various times in the build-up routine, the scope of what is rehearsed and focused should change. As the race start-time approaches, the amount of the race that is rehearsed should diminish by ignoring the last phases. When behind the block and under the starter's control, the content focused on should be a positive, powerful start and transition. When on the block, the visual focus should be on the *"hole"* through which a flat dive will enter the water. The main thoughts should be on the fastest most explosive dive possible. In the ever-present interest of performing a perfect race, the dive needs to initiate the event on a very positive note. The start should be performed exactly as planned. Only thinking of the start will allow a swimmer to control a very high level of physiological arousal that could translate into very fast and powerful movements. At the start of a build-up strategy, the build-up and race strategies are considered in their entirety. The closer the start, the remaining build-up activities not yet performed and the early skills and techniques of the race are of more importance.

Positive self-talk. The metabolic cost of any activity is less when a person is in a positive mood rather than a negative mood (Taylor, 1979). The effects of positive thinking can be generated by the planned activity of saying positive statements to oneself. During a race build-up strategy, positive statements should be recited at various stages. Usually, they will be appropriate for the upcoming race. Some examples of positive self-statements, the likes of which should be included in the build-up routine, are:

> *You feel great today.*

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[8] One great Canadian Olympian preferred to do his imagery when jogging rather than in a relaxed posture and setting. After that was known, other athletes also found imagery *"better"* when walking or jogging.

You will have a very good race because of the preparation you have had.
This preparation will set you up to do a perfect race.
This build-up routine gives you an edge over all other competitors.

The statements are expressed in the second person to give the impression of external, objective control. The use of the first person expression too quickly opens the door for self-oriented states and a resultant inappropriate focus of attention (Staub & Kellett, 1972). Time has to be devoted to formulating such statements, the content of which should indicate confidence in performing very well in a race. The statements can be repeated throughout the build-up and often stated when there is a change in build-up activities.

Physical pump-up. The start of a sprint-race and the level of physical intensity in the swimming and other skills are the most violent (but controlled) in swimming. A swimmer is at a disadvantage to have only a moderate level of physical arousal when on the blocks. Time will be spent in the race adjusting the physiological systems to the level of intensity required. During that period of adjustment, performance efficiency will be less than desirable. Consequently, the closer the arousal-level of the swimmer on the blocks to that which will be required in the dive and ensuing race segments, the sooner peak efficiency in performance will be achieved after the starter's signal.

One task in the build-up routine should be to increase the vigor and intensity of physical activities that are performed as the race approaches. The intensity of warm-up physical activities should match that of the intended performance (Hamar, Gazovic, & Schickhofer, 2000). The amount of physical activity should increase to the point of being almost constant for ~30 seconds before mounting the block. The activities should be total-body exercises involving explosive and comfortable stretching movements. Some swimmers do this naturally and wind-mill their arms very quickly, do deep squat jumps, run (sprint) on the spot, and other vigorous activities. Any activities are acceptable if they do not pose an injury threat and get as close to the race vigor and intensity as possible. Some split-leg vertical jumps should be performed because it has been shown that in explosive movements, it takes several trials to reach peak power. Since a dive is a split-leg explosive movement it should be performed after some *warm-up* jumps. As physical arousal increases so should mental arousal.

One of the difficulties in developing high levels of physical arousal is maintaining mental control. That can be achieved by the mental content being simple. The requirement of a build-up routine to recall each element as well as simplifying the impending task by concentrating on only a few parts of a race as it approaches satisfies that need. Hopefully, a swimmer can be physically and mentally ready to perform a violent start when on the block. That inner intensity should translate into a long flat dive and an almost immediate comfortable transition into effective double-leg kicking after which the race to the 15-m mark unfolds in a superb manner. Highly aroused simple thoughts and physicality on the block should produce a *perfect* start.

Rinsing the mouth with a carbohydrate solution. Rinsing a carbohydrate solution in the mouth has been shown to produce almost-instant performance changes. Most research performance measures have been of an aerobic nature, an activity that relies heavily on glycogen supply for providing glucose for metabolism and energy (Rollo *et al.,* 2009). While it is generally believed that the ingestion of carbohydrate is necessary for performance effects, Gant, Stinear, and Byblow (2009) showed that rinsing the mouth with carbohydrate in solution before ingestion produced benefits before the carbohydrate was systematically available. Mauger *et al.*

(2012) found that rinsing with a carbohydrate solution improve extended performance whereas ingestion did not. However, when the body was in a glycogen depleted state, mouth rinsing did not improve extended performance. Carbohydrate ingestion increased glucose concentrations and improved power output but not overall aerobic performance (Ali *et al.,* 2012). Contrary to the Ali *et al.* findings, Muhamed (2013) reported carbohydrate-rinsing enhanced performance in a Ramadan-fasted state.

Carbohydrate rinsing is an intriguing simple procedure. It has been effective in extended continuous performances. It did affect power output but not overall performance. While it is admitted that much more research needs to be conducted to fully understand the extent of the effects of carbohydrate rinsing, one can resort to several hypotheses.

- A 15-hour day at a swim meet could be considered an extended performance. Periodically, swimming races occur and require exhausting performances. Over such a long period, it is possible for an individual to be slightly glycogen deprived and even dehydrated. Later events in the day could be considered to be analogous to effort bursts in an extended performance. Carbohydrate rinsing could directly affect the performance quality of races occurring later in a day of competing.
- When carbohydrate-rinsing does not affect an overall extended performance it did enhance power output. Since a 50-m race is a power event, it would be wise to include carbohydrate-rinsing in a pre-race strategy as a possible avenue for improving power in the 50-m race.

It is hypothesized that there is a signaling mechanism in the mouth that regulates a central drive that is reliant on substrate availability. The body reacts to those signals before and after added glucose appears in the blood. In one sense, the body takes a risk by trusting that carbohydrate ingestion will follow after the recognition of its potential ingestion from rinsing a solution in the mouth.

Because it requires little effort, carbohydrate rinsing is advocated by this writer as an activity to be included in the race build-up strategy of any swimming race. It can do no harm and possibly can be beneficial for any swimming race because of its effect on power and continued affect over an extended period.

A simple procedure is to dissolve glucose tables in water to make a very strong sweet-tasting solution. It should be taken to the starting block. The rinse should occur within the last two minutes of the pre-race period and followed immediately by the emotional pump-up.. The used rinse should be expectorated into another container.

Emotional pump-up. In concert with the pump-up of physical arousal, the emotions underlying the physical should also be intensified. Emotions that are appropriate are aggression, fury, anger, wildness, violence, hostility, invasion, etc. Whatever emotions are chosen and accompanied by appropriate thoughts and imagery, they should intensify as the race-start approaches. They should peak while standing on the block focusing on an explosive long dive. Such emotions need to be practiced so they can be controlled. Their combination with high levels of physical arousal should translate into an extremely powerful dive. The intensity of the two states should be registered by the power level of the final leg-drive off the front of the block.

Emotional and physical pump-ups can be practiced although in training settings they likely will not reach the level that could be achieved in a competitive setting. The two forms of pump-up should impress swimmers as to just how important it is to perform a dive that has the same physical characteristics as those to be evidenced in the rest of the race.

Focus on start with maximum intensity. The race build-up routine is a procedure whereby a 50-m swimmer mounts the block with maximum intensity (readiness) to perform a perfect start, to be ahead at the 15-m mark, and complete a perfect race for a best-ever performance. If the maximum readiness does not exist, then at best, it will have to be developed in the early stages of the race losing any opportunity to gain an advantage while the adjustment takes place. It has been known for years that such adjustments are slow rather than fast (Astrand & Saltin, 1961; Bickelmann, Lippschutz, & Weinstein, 1962; Guyton, 1963; Margaria, 1963, 1964; Schneider & Karpovich, 1948). It is for that reason that the preparation for a 50-m race is as important as the race itself. Without an effective relevant preparation, a perfect 50-m race is very unlikely.

The pre-race build-up routine is developed and practiced so that: i) physical arousal is as close as possible to the level of arousal needed to complete a total perfect 50-m race, ii) mental activity is totally focused on all aspects of the 50-m race, and iii) a swimmer's self-efficacy is very strong and notably absent of any negativity. Anything less than those three race-preparation characteristics will result in a less than desirable performance relative to the goal of performing a perfect race.

There are several purposes underlying a race build-up routine.

- Emotional control should peak as the start begins.
- Thought control is to be on the task and preparations.
- Focus and thought control should progressively narrow as the build-up routine progresses.
- The highest energy readiness and the narrowest focus should be timed with the start.
- The deliberate control of emotions and focus are always maintained.

Race Build-up Routine Example

Exhibit 1 is an example of a well-used race build-up routine for a 50-m event. Swimmers should write out all that should be done and structure each event as illustrated.

1. The *Primary Behaviors* column has each set of activities listed in order.
2. For each entry in the *Primary Behaviors* column an alternate set of behaviors should be formed and entered in the *Coping Behaviors* column (see previous explanation). Overall strategies and mental control are improved if coping strategies are included to prepare for circumstances when the primary behaviors do not work.
3. The *Outcomes* column indicates what should result from performing both primary and coping behaviors.

A race build-up strategy is incomplete and potentially less effective if the three columns are not completed. Their structuring will take more time than if only primary behaviors are described. The outcomes that are listed are the goals of the activities. They should result from the activities. Most importantly, they serve as the trigger for moving onto the next element in the routine. It is important that any sport-related preparation and execution be process-oriented. In that sense, the third column is the most important for it lists the states, feelings, and performance assessments that must occur to reach the best state of readiness for a race.

STRATEGY PLANNING WORKSHEET

Page ....2...

Primary Behaviors	Coping Behaviors	Outcomes
Race Build-up Routine		
1. *Three rehearsals of build-up routine and race*	*Three rehearsals of build-up routine*	*Readiness begins*
2. *Stretch 10 sites and movements; dress warm*	*Bounding and rolls*	*Loose and warm*
3. *Walk away from the pool - Note time*	*Jogging with strategy rehearsal*	*Active*
4. *Positive self-talk; drink*	*Positive imagery*	*Feel great*
5. *Isolate and disappear*	*Keep moving*	*Isolate*
6. *Perform four race rehearsals with movements*	*Rehearse sections*	*Race details*
7. *Increase movement speed*	*Explosive squat jumps*	*Movement ready*
8. *Some sprints and squats at start intensity*	*Continue until level achieved*	*Intensity ready*
9. *Three race rehearsals with movement*	*Rehearse section*	*Race awareness*
10. *Positive self-talk; image aggressive swimming with much energy*	*Make body be ready*	*Terrific feel*
11. *Mind and body both together for final build-up*	*Practice some physical pump-up activities*	*Ready to go*
12. *Check suit, goggles, and hat; drink; active*	*Keep self-talk going*	*Final stage*
13. *Emotional pump-up; smash the pool*	*Fearless and on-the-edge*	*Peaking*
14. *Physical pump-up; bigger movements; stretch in race rhythm*	*Act out first length*	*Powerful*
15. *Focus on start; leg power and speed; streamline*	*Practice posture and reaction*	*Explosive*
16. *Walk to start; image segments; extra acts*	*Physical and mental pump-up*	*On the edge*
17. *Rinse mouth with glucose solution*		*Feel power*
18. *Intensify to race readiness*	*Work physical pump-up more*	*Very powerful*
19. *At block/lane; image; physical/mental pump-ups; only look at the lane and walls*	*Feel everything*	*In control, and ready*
20. *Locate entry hole in water; check kicker*	*Continuous movement*	*Intense*
21. *To race strategy*		

Exhibit 1. A sample pre-race strategy for a race build-up routine for a 50-m event.

Race Build-up Strategy Preparation

A race build-up strategy is a detailed developed set of self-instructions that will guide a swimmer to prepare for a 50-m swim in the most effective manner. It involves the various emotional and physical states that a swimmer should experience prior to a race (the content in the *Outcomes* column). It provides two options for achieving those outcomes. The *Primary Behaviors* are the preferred activities to achieve an outcome. When a primary behavior does not appear to be *"working"* (i.e., not moving toward producing the outcome), a swimmer can switch to performing the *Coping Behavior* and increase the likelihood of achieving the same outcome. Just having the coping behavior increases the probability that the primary behavior will be effective and produce the stated outcome.

The strategy is not quite the equivalent of an actor's script for a role. It does contain word-specific content in the form of positive statements early in its development. Its primary effect should be to provide a swimmer with ~30 minutes before a 50-m race where self-control and behavioral successes occur continually and produce a high degree of self-efficacy (i.e., positive performance prediction) for achieving continued successes in the race once it starts.

Pre-race strategies are developed continually. There have to be changes invoked when situations are altered, the swimmer matures, or the swimmer joins a new training environment. With each improvement demonstrated at training, which in USRPT terms should occur daily, changes need to be made.

Initially, the swimmer should be required to write on structured three-column paper as illustrated in Exhibit 1, all that he/she needs to do to achieve the best race-readiness when preparing to step up on the block for the race-start. The order in which the two forms of behavior and outcomes are recorded varies because of the individual nature of each swimmer for attacking the task. The preference would be for swimmers to first define the outcomes that are to be achieved. Usually, the coach or performance psychologist would describe what outcomes are, how they should be expressed, and suggest the order in which the various outcomes occur, which has been described at the start of this section. Swimmers' attempts should be critiqued with suggestions for omitted steps to be included, the removal of negative expressions (e.g., *"don't lose focus"*), and particular details of what happens in the last five minutes or so.

After each 50-m race, not only should the swim be evaluated but so too should the race build-up strategy, particularly looking for what did and did not work. If strategies are written in pencil, then the failed behaviors can be erased and new behaviors inserted. The testing of those new behaviors for effectiveness should be part of USRPT sessions, particularly before the water is entered at the commencement of practice.

Pre-race strategies should be taken to every meet where a 50-m event will be swum. If a swimmer loses focus or is distracted in some unplanned way, focus/control can be regained by reading the strategy and referring to it as an appropriate stage is acted to return to the progressive development of race-readiness.

As strategies are experienced, some details will be omitted and the activity shortened. For example, a dynamic stretching routine should only have to be mentioned for the swimmer to engage in a series of exercises that prepares the swimmer's total body for the impending race. Exhibit 1 is an example of an advanced stage of development of a race build-up strategy. Exhibit 2 is an earlier version of some of the events in Exhibit 1 and illustrates the initial details that have to be recorded.

One might think that in time swimmers will learn the steps to progressively develop race-readiness for a 50-m event. A 50-m event is unique in that no segment of the race is repeated in a manner similar to longer races where laps are performed at a steady pace and can be influenced by repeating the same strategy to produce the steady-state performance. It is this writer's recommendation that one never takes for granted that a swimmer *"knows what to do"* prior to a race to achieve the most desirable form of race-readiness[9]. Although a tedium to some, those likely to be great champions will not pass up the conservative behavior of always preparing for competitions in the most beneficial manner no matter what the competition. Lesser competitions are but training opportunities for important competitions. Prior to an Olympic final, a swimmer should know what to do to perform one's best in that single chance of a lifetime.

STRATEGY PLANNING WORKSHEET

Page ....2...

Primary Behaviors	Coping Behaviors	Outcomes
Race Build-up Routine		
1. *Three rehearsals of build-up routine and race*	*Three rehearsals of build-up routine*	*Readiness begins*
2. *Stretch 10 sites and movements; dress warm* *Ankles, hips, back, shoulders, neck*	*Bounding and rolls* *Back and forward rolls*	*Loose and warm*
3. *Walk away from the pool - Note time* *To hallway under the stands or go outside*	*Jogging with strategy rehearsal* *Go outside*	*Active*
4. *Positive self-talk; drink water* *"You have done the training"* *"Training improved now show it in the race"* *"Rested and ready"*	*Positive imagery* *"Image winning at last meet"* *"Recall successful training"* *"Feel better than previously"*	*Feel great*
5. *Isolate and disappear* *Sunglasses and earphones*	*Keep moving* *Look at no one*	*Isolate*
6. *Perform four race rehearsals with movements* *Arms move at race rate* *Continue until exact timing*	*Rehearse sections* *Time the rehearsals* *Time sections of the rehearsal*	*Race details*
7. *Increase movement speed*	*Explosive squat jumps*	*Movement ready*

Exhibit 2. An earlier more detailed version of a section of the race build-up strategy included in Exhibit 1.

Swimmers should learn and follow the content of a race build-up strategy script exactly so that they are totally certain of what to do.

Race Strategy

A 50-m race strategy involves all activities from when the swimmer comes under the starter's control until the touch has been completed on the finish wall. The beginning of the race strategy should flow seamlessly from the race build-up routine. That linkage signifies that a race actually

[9] Some of the world's most famous performing artists, such as the singer the late Elvis Presley, review the words of their songs and roles before performing. Some individuals do not do pre-performance rehearsals and preparations that are consistent, but one could argue that their performance standards will be more variable than those who have to produce a consistently exact high-level of performance and its characteristics. In this writer's close to 50-years of performance psychology practice the opinion and practice has been formed that athletes must always develop and be consistent in pre-competition strategies.

starts with the initiation of the race build-up strategy. A race strategy must include a number of cognitive structures and activities.

Segment the Performance

Extended complicated performances are completed with higher levels of performance when they are broken into smaller parts (segments), all being concentrated on exclusively when they are appropriate for a stage of a race. Races of 100 m or more often have steady-state stages where the manner of completing laps is repeated. In such circumstances, a race strategy would have sections that are repeated to accommodate the even race-pace that is required of tasks that are not maximum efforts. However, a 50-m race does not have any segments that are repeated.

The racing-skills section of this manual has defined the common stages of a 50-m race. They are in order: Mounting the block, the dive, the transition from the dive to surface swimming, reaching the 15-m mark, surface swimming to 40 m, the approach to the finish, and the finish. In SCm/y 50s, a turn is required. For this discussion only the long-course 50-m race will be considered.

The first task is to develop the stages of the 50-m race which were listed above. At practices and in races, the segments of the race are focused on in order. One does not think of the race finish until the wall touch is appropriate. While double-leg kicking in the dive-to-surface-swimming transition, executing the fastest underwater work should occupy a swimmer's complete attention despite it lasting only for a short time. Each segment of a race requires a swimmer's undivided concentration so that no distractions outside of the swimmer's performance are attended to. If a swimmer's thoughts *"wander"* and attend to features outside of one's own performance, the probability of errors in performance, lessening of effort levels, increases in performance variation, etc., occur. Every resource at a swimmer's disposal should be used to govern a performance. No benefit can be derived from focusing on features that are not associated with a swimmer's own performance.

At the end of each segment there should be a performance goal. Sometimes a goal is purely time, but more commonly the goal is the complete correct execution of the segment. One does not think of a segment until it is time to initiate it.

Serially completing the segments of a 50-m race with complete attention and use of mental facilities is the central task of any sprinter wanting to achieve a maximum performance. A segment is only considered when it is appropriate as a race unfolds. Race-segments are often units of mental rehearsal, particularly when learning something new for that portion of a race. A race-segment contains the thoughts that will be entertained and if that is done correctly, segment-goals will be attained.

After a race is completed, one aspect of a post-race analysis should be evaluating the adequacy of segment performance and an assessment of each segment's goals for what was and was not achieved.

Task-relevant Content

How a swimmer thinks during a race will govern performance. Various types of self-talk have been shown to elevate swimming performances (e.g., Shewchuck, 1985). Of particular importance is the positive effect of three types of thoughts on maintaining swimming technique (form) and propelling efficiency. Task-relevant (i.e., swimming-relevant) content is the first classification of self-talk content that benefits swimming. It is particularly important for use at training when attempting to alter surface-swimming techniques and racing-skills.

The thoughts that are used need to meet a number of criteria.

- The technical and tactical aspects of a race need to be developed. If this is done, then a good race result or training effect will be achieved.
- Task-relevant content should constitute about two-thirds of all race thinking. This feature is important for all races other than 50-m events (see below).
- The wording used should be specific (not general). Direct changes to performance should result. In one sense, one should talk to their muscles. For example, a general self-instruction could be *"streamline"*. Using that word might or might not produce an effect. However, if specific instructions such as *"hips level with the shoulders"*, *"back of head level with top of back"*, and *"keep kick within your frontal profile"* are used, body reactions or maintenance should ensue to produce good streamlining. Direct task-relevant self-talk is sometimes likened to self-coaching and so the wording has to be directive.
- Associated with the above bulleted point is the requirement for any discrete task-relevant self-direction to produce a specific outcome. An external observer, such as a coach, should be able to see the results of a swimmer's self-talk in the way that he/she is swimming.
- When task-relevant thinking occupies a large amount of a swimmer's thinking at practices, if limited expressions are used they are likely to become ineffective. Consequently, varieties of expressions need to be devised all producing the same outcome. When self-talk involves varieties of expressions, an athlete's responses maintain their vitality and effectiveness is consistent. For example, a variety of expressions concerning the head position in crawl stroke could be:
    - *Water flows over the top of the cap.*
    - *Chin close to the chest.*
    - *Lengthen the back of the neck.*
    - *Look directly at the bottom of the pool.*
    - *Face parallel with pool bottom.*
- One very beneficial use of task-relevant self-talk is when fatigue begins to be noticeable. Concentrating on how swimming techniques are being used often stalls the recognition of fatigue. As well, task-relevant content should be designed to preserve good swimming technique despite the accrual of fatigue. The reason it works is that it sustains propelling efficiency if that is the focus of the thinking. When an individual confronts fatigue by trying harder, the unfortunate result is that fatigue is accelerated and the break-down in technical efficiency, which is the first feature of fatigue, is quickly noticeable. When fatigue is recognized by a swimmer, the trained response should be to swim *better* (i.e., preserve technique), not *harder.*

Swimmers should always be thinking of something that has been planned at practices and in races. There is no excuse for a swimmer losing focus. If a distraction occurs and a swimmer realizes that, a common entry point into focused thinking is to begin self-talk (i.e., self-coaching) with task-relevant content.

Mood Words

Mood words set the mood and character of a performance. They are usually single primitive words which if said with appropriate emotion cause a type of action to be increased. In 50-m swimming races, speed and power are very desirable performance characteristics. To move fast, any of a number of synonyms might be said or thought of in a brisk sharp manner. The same applies to power, another desirable swimming feature. Some possible synonyms are:

Speed fast, lunge, thrust, jab, rap, smack, brief, flick, whip, fling, pop, dash, quick

Power might, force, heave, impel, smash, snap, rip, blast, boom, bang, thump, explode, drive

Mood words are often said to embellish the impact of task-relevant thinking. For example, if the arm entry at the catch to the first part of the propulsive phase of a stroke should be as fast as possible, thinking *whip*, *snap*, or any meaningful word denoting speed at the moment the arm is about to enter the water should promote a faster repositioning of the arm (see Section 1).

Performing in a 50-m race requires the fastest most-powerful swimming strokes. The effort level to achieve speed should be quite high but not excessive. It has been shown that if a swimmer achieves maximum velocity and increases the effort level further no increase in swimming velocity results from the *harder* effort (Capelli, Pendergast, & Termin, 1998). At high effort levels, performance improvements are more likely to occur through more precise technique emphases than extra effort. It is proposed that sprint-swimming speeds are more likely to improve when surface swimming techniques are emphasized rather than physical effort.

However, when movements are very fast, the cognitive control exerted by thinking and self-talk is limited. When too much self-talk is attempted the duration of the expression could exceed to duration of the movement. There is no dispute that to change or control a swimming technique task-relevant thinking is necessary no matter what the stroking speed. Much of practice thinking even when swimming as fast as possible will have to emphasize at least one stroking element to improve propelling efficiency. But, in sprint races the potential to inhibit maximum speed swimming exists if too much technique detail or self-talk is engaged in. Consequently, in 50-m races the proportion of task-relevant thinking is much less than at training. As replacements for task-relevant self-talk, mood words should be preferred. For example at training, repeatedly thinking about changing the orientation of the forearm-hand propelling surface from horizontal at entry to vertical well in front of the swimmer has to be engaged in if a sound repositioning action is to initiate both arms in crawl stroke. When sufficient practices of that action are completed[10], mood words should gradually be used to produce a simple control signal as opposed to the complex relatively time-consuming multiple-worded task-relevant instruction. Eventually, but later rather than sooner, mood words should be used to govern the intensity and precision of sprint swimming techniques rather than task-relevant self-statements despite both having the same meaning.

Mood words should be emphasized in the strategies of 50-m races whereas task-relevant thought content should be emphasized when practicing for stroke improvements.

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[10] The actual number of strokes that determine sufficient practice varies considerably between individuals and the nature of stroke repositioning before the advocated action is attempted. Most swimming coaches vastly underestimate how much practice needs to be completed to achieve a permanent movement change. For starters, the time estimate should be thought of in terms of months of practice which translates into many thousands of repetitions of individual strokes.

Positive Self-statements and Self-talk

The third form of self-talk that affects the quality of a swimming performance is positive self-statements. A positive mind-set in a performance maintains application effort and physiological efficiency (Taylor, 1979). For races longer than 50 meters, phrases should be developed for self-encouragement, effort control, segment goals, and general positive self-talk (Rushall, 1995). Since longer races are less frenetic than the shortest sprint race, the use of full phrases is possible and they should be interspersed throughout the race strategy. However, for 50-m events, maintaining a positive orientation is adequately achieved by using single words that have strong positive connotations. When thinking of these words they should be expressed with a strong emotional emphasis. Positive words with influential meaning are particular for each individual. The following list contains words that might be used for positive utterances.

> *good, top notch, capital, first class, first rate, magnificent, stupendous, superlative, radical, super, fabulous, amazing, far-out, dynamite, phenomenal, tremendous, gorgeous, a-1, grand, beautiful, incredible, fantastic, proud, superb, splendid, right on, hot, magnifique, terrific, great, marvelous, wonderful, excellent, unbelievable, out of this world*

One particular use of positive statements in any race is for the evaluation of whether or not a segment goal has been achieved. In a 50-m race, if a particularly quick analysis of a segment as it is being completed indicates successful achievement, a quick enthusiastic positive utterance will serve as a positive reinforcer for the race quality being produced. Planning on what and how positive words are to be expressed would allow their use to signal the start of the race's next segment.

Integrating Strategy Components

A 50-m race strategy is a plan or script of what to think of during a race. It should be detailed to the point that when a statement is used, there is a direct physical reaction. Approximately two-thirds of the strategy should be task-relevant content. The remaining third should be mood words and positive statements/words. Mood words should be spread throughout a race strategy and should provide enthusiasm for the task-relevant content in the segment in which it is used. Positive self-talk comprised mostly of single emphatic words, should also be spread throughout the strategy although more likely used for positive evaluations of segment performances.

The content of the strategy should be tested and practiced during USRPT sessions. Since the content will have been developed and only included if it is beneficial, then using it in a race will result in close to, if not the best performance possible. To avoid distractions that could intrude into a race execution and create openings for loss of control and errors, there should be sufficient content planned to occupy a swimmer's thought processes for every moment in a race. Anything less than 100% focus is likely to cause a performance to be less than that which is possible.

As a strategy is developed, its components should occupy the thought contents of repetitions at practice when directed by the coach to do so.

Coping Behaviors

As with the race build-up strategy, for every primary behavior in a race strategy there needs to be an alternate coping behavior. The coping behaviors mainly consist of secondary thought structures to achieve the same performance outcome as the primary behavior.

A 50-m race is such a short event that there is little time during its occurrence to analyze what is happening and decide whether or not to switch to a coping strategy in one or more of the race's segments. To facilitate the coping mechanism, at training sessions swimmers should practice switching from primary to coping strategy content half-way through designated segments. Having confidence in either alternative for achieving desirable outcomes will bolster a swimmer's self-efficacy for the race.

There are happenings around a race that require swimmer's to cope with unplanned events. Appended to the end of a race strategy should be coping behaviors for responding to the following problems.

- Loss of control (e.g., losing focus on the prepared content for one or more segments).
- In-race distractions (e.g., thinking of another competitor or position in a race).
- Pre-race distractions (e.g., someone false starting).
- Delays before the start but when ready to mount the starting block (e.g., a problem with starter's signal).
- Excessive tension (e.g., usually before mounting the starting block.
- Missing strategy content, failing to achieve a segment goal, or performing a poor turn.

The coping list is likely to grow as a swimmer gains experience through competing in many races.

Psychological Intensification

Psychological intensification is a procedure to enhance the maintenance of control and focus. It is a topic that is rarely discussed in the literature because it was developed in this writer's laboratories during his full-time academic career (e.g., Johnson, 1991; Martin, 1989). The theory behind the procedure is in concert with Melzack and Wall's *Gate Theory* (Melzack & Wall, 1965; Wall, 1978).

An interpretation of the practical use of *gate theory* is this. When the brain is fully occupied with thinking (i.e., central nervous system activity) forms of sensory input are blocked, that is, the *gate is closed.* As external sensory input increases, for example pain increases, it can still be ignored if the intensity of thinking is increased by a commensurate amount. Since the pain associated with fatigue in intense exercise is similar to the pain of injury and painful stimuli, strategies to occupy an athlete's thinking and the progressive increase in the intensity of that thinking stays ahead of the negative physical stimulation, causing performance quality to be maintained. Any glitch in the brain's activity that reduces its involvement can lead to the gate opening and the pain of fatigue being recognized. In intense activities it is relatively simple to see *when the gate has opened* – the quality of technique deteriorates very rapidly, the velocity of swimming lessens, and in the long run, neither technique nor performance quality recover. For psychological intensification to work in a 50-m sprint, mental activity has to increase markedly to block the recognition of fatigue caused principally by hypoxia. Deliberately employing psychological intensification in a race before it is actually needed is a procedure that will guard against complacency, loss of control, and *"dead-spots"* (gaps in the thinking process that are unrelated to the racing task).

As a 50-m race progresses, intensification could take several forms. Swimmers should experiment with some of the forms and select the one that seems to work best and with which the swimmer is most comfortable. Some single forms of intensification follow.

- ***Thinking faster.*** As the race progresses more words are processed per unit of time. An added advantage of this option is that as fatigue tends to slow stroke rate, thinking faster can reduce the size of the rate drop.
- ***Thinking harder.*** This is achieved by concentrating harder on what is being thought. Swimmers approach this option from individual perspectives some of which are successful while others are not.
- ***Thinking louder.*** As the race progresses, the volume of a swimmer's thoughts increases to the point that in the last stage of the race, the thoughts are being screamed but in an understandable tone.
- ***Picturing.*** Since strategies are written down, picturing strategy sheets and reading what is on them serves as an intense activity. As fatigue increases but before it is recognized, one successful ploy is to see what has been written but in larger letters. As the race progresses, the size of letters continues to increase.
- ***Muttering.*** This is a common ploy with terrestrial sportspersons. In swimming it is talking to oneself with progressive intensity so that at the end of the race, a swimmer is mentally coaching him/herself with great intensity and enthusiasm.

In some cases it is useful to mix two and rarely three forms of intensification. Thinking harder and louder is considered an easy way to understand how to intensify. The central feature of all the options is that the brain will have to work harder at concentrating on the race strategy content as the race progresses. That keeps *the gate closed* to fatigue recognition.

Intensification is as important as the verbal content that is devised for a 50-m race. The mix of intensification and mood words yields very significant effects in explosive power events, of which a 50-m sprint is an example. At practices, swimmers should employ intensification on any form of mental activity as repetitions become more difficult due to fatigue. How intensification is to occur should be recorded on the race strategy sheets.

Exhibit 3 is an illustration of the concept of intensification.

Recovery

The following are suggestions for recovering from a 50-m race.

- Swim continuously for 5-10 minutes at a rhythmical pace (equivalent to that to be used for a 3,000 m swim).
- Replenish fluids and carbohydrates with food or drink (e.g., low fat chocolate milk).
- Follow the swim down with a warm to hot shower.
- Dress warmly and comfortably.
- Lie down with feet elevated or up against a wall. Do this for 5-10 minutes.
- Go to a quiet area where the completed race and its preparation can be analyzed. Make notes on the strategy sheets of what did and did not work satisfactorily.
- Confer with the coach about changes in the strategies as well as what activities will be retained. Only do this if the coach is free and can totally focus on the revisions.
- Alternate five 5-10-minute periods of reclined inactivity with rhythmical activity such as walking while doing dynamic stretching exercises.
- Periodically while reclined do mild stretching exercises.
- Establish a time when you will start to think about and commence preparing for the next race.

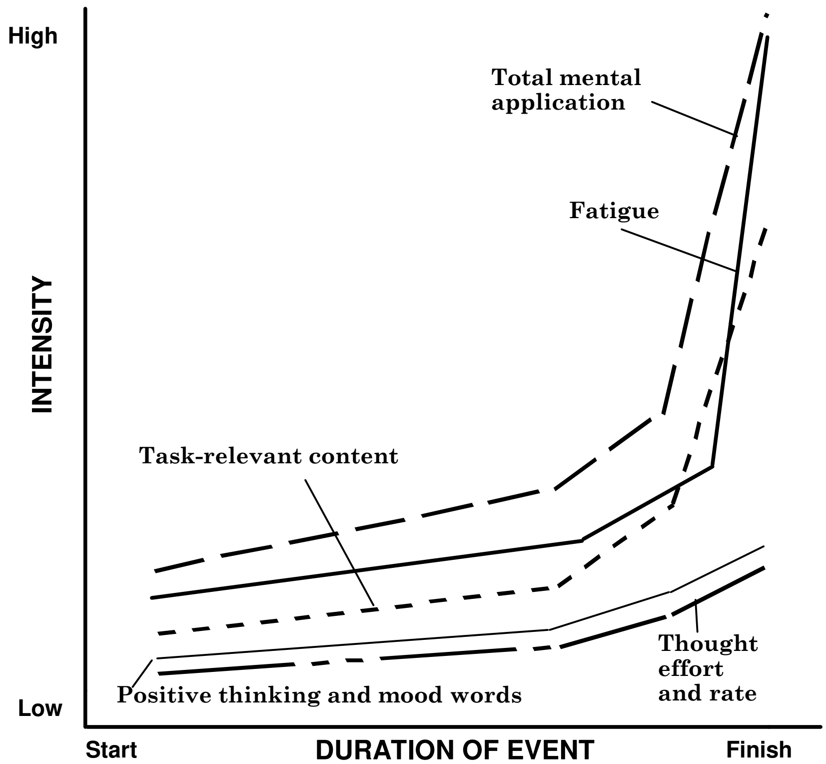

Exhibit 3. The concept of intensification showing that the total mental application (thinking) is always increased before the next increase in fatigue (pain) intensity.

Avoid the following.

- Activities that are boisterous or likely to cause emotional outbursts or even injury.
- Getting cold.
- Remaining inactive for any extended period (>10 minutes) except in the case where some sleep might be needed.
- Participating in physical activities not associated with swimming.
- Doing too much warm-down.
- Doing too much of one activity in the warm-down.
- Attempting to do things in a warm-down that cannot be performed satisfactorily (e.g., a crowded lane that prevents unhindered swimming).
- Persons who have had a bad swim, are talking negatively or complaining, or being with people who might be confrontational.

A general plan of activities should be structured for a post-race recovery. It need not be as detailed as the pre-race and race strategies but should be sufficient to avoid doing unplanned activities that might lead to injury or excessive fatigue.

Debriefing

After every performance, both the race build-up strategy and race strategy should be reviewed to decide what worked and did not work satisfactorily for the event. At the venue while the event is still fresh in the swimmer's and coach's minds, alterations should be made with the intention of improving the strategies. Thus, a USRPT swimmer has a different post-race regimen than traditional swimmers (most of whom would not have detailed preparation and execution strategies). Items that remain and altered or new items introduced post-race should be practiced at ensuing training sessions. Based on what happens using strategy content at training sessions, it is possible that the strategies could be changed further.

Learning Race Strategies

If the race strategy has been learned, as the race unfolds strategy phases should be recalled and followed. At no time in a 50-m race should the mental activity include the need to think of what is next. A need to recall some feature of performance introduces a performance-irrelevant cognition. In a brief period like that, errors could be made by the swimmer which would prevent attaining the goal of a perfect race.

Race strategies should be written in pencil on a formal strategy sheet (see the previous race build-up strategy examples and the following Exhibit 4). They should accompany a swimmer to every practice and race. If beneficial experiences occur at practice and are race-relevant they should be entered into the strategy before leaving the practice facility. Usually, such changes are only made when they consistently show improved swimming performances.

Both race build-up and race strategies evolve over time. They often need to reflect changes in technique and competence that occur from properly structured USRPT. A major purpose of USRPT is to change swimmers for the better at practices. Consequently, race-strategies should reflect successful improvements that have occurred at practices between swim meets.

Race-strategies are the substance of performance enhancement imagery. The imagery is employed in the race build-up strategy. Repeated imagined races or parts of races involving strategy content at practices is one way of learning the content so that it acts as an automatic script for the next race performance.

Both race build-up and race strategies should contain only activities and thought structures that have been practiced. The mantra of *nothing new at races* should be strictly heeded. If only practiced content is employed in a race then performance should be predictable and reliable. However, if something that has not been done before is attempted, there is no certainty with its predicted effect. As a rule-of-thumb, when something that has not been practiced is attempted, performance worsens rather than improves. Improvements only occur with sufficient and necessary specific practice.

The Overall Goal of Competing

The goal of competing should be the perfect execution of a strategy. Winning is not important but performing one's best is!

Any competitive performance must be the best that can be produced. That should maximize the learning value of a race and should develop the consistent attribution of contests being maximum efforts for goal attainment by using existing resources. A race reveals how effective the past training has been. If relevant performance-improvements have occurred at practices, they should be transferred to the next race.

A heat that is less than one's best has drawbacks.

- Not much of value can be practiced and transferred into a semi-final or final.
- It is a practice of doing less than one's best. It makes it easier to do less than one's best on other occasions that is, it practices quitting and going easy as well as making it easier to give up in difficult competitive circumstances.

- The vast change in expectations and appraisals between "*easy*" heats and "*hard*" finals does not allow adequate preparation. The "*easy*" heat does not rehearse and prepare the necessary ingredients for a maximum final's performance.

If one "*saves*" in a heat then there is not much that can be transferred to a final. It becomes a completely new event. Thus, at the final there is a greater degree of uncertainty, which produces the possibility of anxiety occurring.

A heat should be an honest effort to achieve excellence. The demands of a 50-m race are not excessive and so recovery between heats and finals is manageable. Further, if a swimmer has trained well and sufficiently, and has the right diet, recovery between hard heats and finals should be total.

One option is to take the best aspects of what was done in an "*honest*" heat, correct any imperfections by introducing items that have been practiced and shown to be successful, and then swim the best heat aspects plus the improvements for an even better final performance.

There can be no substitution for practicing the best that one can do for learning purposes and preparing for the next performance. In a race, thinking of events and items outside of a swimmer's self-control would introduce content that is irrelevant for a swimmer's own performance. There is no value to paying attention to non-self (irrelevant) stimuli. Each distraction that interrupts a swimmer's focused attention will slow the performance noticeably.

An Example of a 50m Race Strategy

Exhibit 4 is a sample 50-m long course freestyle strategy. Some key features of several segments are included. The majority of thinking for each stage consists of mood words. It is assumed that each mood word has been linked to certain technique elements through repetitious training.

If all training swims require mental content that is race-specific to be included, it should be possible for swimmers to execute skill elements effectively in races by replicating the practiced thought content. To maintain thought control, the intensification procedure of thinking louder, even to the point of screaming is used. Some race segments, such as lunging for the wall to finish, happen so quickly that only a few thoughts/words are possible. Those few words are sufficient to keep focused on producing skilled technique or race elements when needed.

A 50-m race normally involves less than 20 seconds of swimming after the anomalous dive and transition to surface swimming segments are completed. Some form of thought intensification should be possible to foster full focus on relevant race-elements for the entire race. Achieving that focus should be a constant demand of effective sprint coaching.

STRATEGY PLANNING SHEET

Page ___*1*

Primary Behaviors	Coping Behaviors	Outcomes
AT BLOCKS		
"Fast, fast, fast" - kill that water	*Whirl arms as fast as possible*	*Feel very quick*
Look at dive hole – spear in	*Big leg drive to get out*	*Focus on dive*
Feel the water on forearms	*Lock arms in the water*	*Main focus*
Jump, stretch, and kill; feel GREAT	*Violently active*	*Powered-up*
Goal: *Fired up - just under control*	*Focus on the water*	
THE DIVE		
"BANG" long; first to enter	*Reach for the pool end*	*Dive distance*
Max streamline - tight arms and toes	*Spear into the water*	*Streamline*
Goal: *Go far fast; TOP DIVE*		*Shallow*
TRANSITION		
Kick for doubles super fast speed	*Drive forward with small kicks*	*Keep dive speed*
Smaller kicks faster rate	*Push with top of foot*	*Small and fast*
Pull to surface - mighty heave	*Look for surface, ROCKET*	*Burst to surface*
Goal: *High speed to swimming, FAST*		*Top speed*
SURFACE SWIMMING TO 15 m		
Accelerate, thrust, THRUST, GREAT	*Push forearm back*	*Propel*
Goal: *Through 15 m very fast, WIN*		
SWIM TO 40 m		
Long stroke, long, LONG	*Thrust from in front*	*Stroke length*
Lean shoulders, PUSH, SHOVE	*Shout LONG, PUSH*	*Stroke strength*
Attack entry, yell ATTACK, ATTACK	*Short time in front, QUICK*	*Stroke rate kept*
Concentrate QUICK SHOULDERS	*Roll fast*	*Keep rate*
40 m near LONG DRIVE	*LONG THRUST*	*Maintain power*
Goal: *Maintain stroke length and power*		
10m TO GO		
Recover fast NEXT STROKE	*Concentrate – continuous push*	*Rate up*
Head down, DRIVE BACK, EXPLODE	*Accelerate SCREAM*	*Faster*
THRUST to wall	*Continuous push*	*Constant push*
HEAD DOWN LUNGE - TERRIFIC	*Bang timer*	*Trip timer*
Goal: *Faster finish, FELT GREAT*		

Exhibit 4. A sample race strategy for a 50-LCm race.

Section 5
CONDITIONING

USRPT is based on scientific findings (Rushall, 2015). It justifies the use of short-work short-rest (ultra-short) interval training as being preferable to longer-work longer-rest interval training and continuous training (traditional or common swimming training). In just about all matters that are of concern to swimming coaches, the ultra-short training format produces training effects faster and to higher levels than traditional training (Rushall, 2014b). As well, the ultra-short format facilitates instructional opportunities more frequently and enhances opportunities for different sources of feedback other than the coach. While USRPT has caused negative reactions from many entrenched coaches who mostly do not understand it (Rushall, 2015b, 2015c) it continues to grow in popularity and media attention. Training that does some race-pace work is not USRPT.

The *Preface* to this manual listed several factors that require USRPT for 50-m races to be different to standard USRPT. Those distinguishing features have to be accommodated in 50-m race work. A brief restatement of them follows.

- So much in technique and racing skills has to be learned, refined, or overlearned that the restricted time that can be devoted to repetitions of important elements of 50-m racing poses a serious challenge. The preferred alternative is to have every stroke and skill executed at practice as best as it can be. The intense motivation to change in the directions stipulated by the coach separates 50-m training from that employed for all other areas. *A stroke at practice taken without intent is a wasted stroke.*
- A 50-m race comprises a series of racing skills plus surface-swimming technique all influenced by the thought content stimulated by planned race strategies. Every stroke at practice should be accompanied by specific race-relevant thought content. For swimmers who come from a background of swimming for conditioning and never being encouraged to think every stroke with useful thought content, the development of desirable concentration is a demanding task that takes considerable time.
- The intensity of each training stroke and skill practice is the highest in all of swimming. That intensity should focus on speed of movement, not effort. In high-velocity sports (e.g., track sprinting, kayaking, rowing, sprint cycling, etc.) it is recognized that effort levels have to be high but not so high as to tie-up the body's resources for producing movement speed. For want of a better description fluent, relaxed, maximum speed movements should be practiced. Attempts to go faster should come from technique/skill improvements not *extra effort*. In any practice or racing situation where faster swimming velocity is required, swimmers should respond by seeking greater speed of movement while holding the effort level in check. Maximum effort responses fatigue athletes faster, cause many muscles to contract unnecessarily to the point where the working muscles have to overcome the counteracting increased antagonist muscles' tension and friction, and usually slow the overall performance. The dedication to movement speed in swimmers will be a new experience for many because most will have grown-up in a *work-harder orientation* to exercise intensity. Sprint swimming races should be dominated by speed of movement efforts, not strength or muscle-recruitment orientations.
- The major departure from standard USRPT is that for 50-m race training, recovery between repetitions has to be nearly complete, a level acceptable to and nominated by the

swimmer. Allowing swimmers to determine recovery is somewhat similar to the physiological recovery principle required for the original interval-training format described by Gerschler (1963; also see Rushall, 2015d).

- During the prolonged recoveries, there is much time when feedback can be provided about the feature focused on in the element just practiced. As well, in the between-repetitions recovery, the plans for the next repetition should be formulated in detail, even if they are another repetition of what was just attempted. In interval training, each successive repetition should be the completion of what was done well in the previous trial plus improvements that were determined from the feedback following that trial. Replay video is an excellent tool for self-reinforcement and evaluation during the recovery periods[11].
- The physiology of a 50-m sprint is largely unknown because of the difficulty in measuring oxygen use when breathing does not occur. Troup (1990) estimated that 31% of energy use was aerobic and 69% anaerobic. Gas samples were obtained through use of a snorkel mask during swimming in a flume. It is known that wearing a snorkel alters the mechanics of stroking (Strumbelj, 2007). Despite that confounding factor, Fernandes *et al.* (2013) measured oxygen kinetics during a maximal 50-m front crawl effort by having swimmers wear a snorkel in an *AquaTrainer* flume. Figure 1 shows a steeper utilization curve after approximately 40% of the Fernandes *et al.* task.

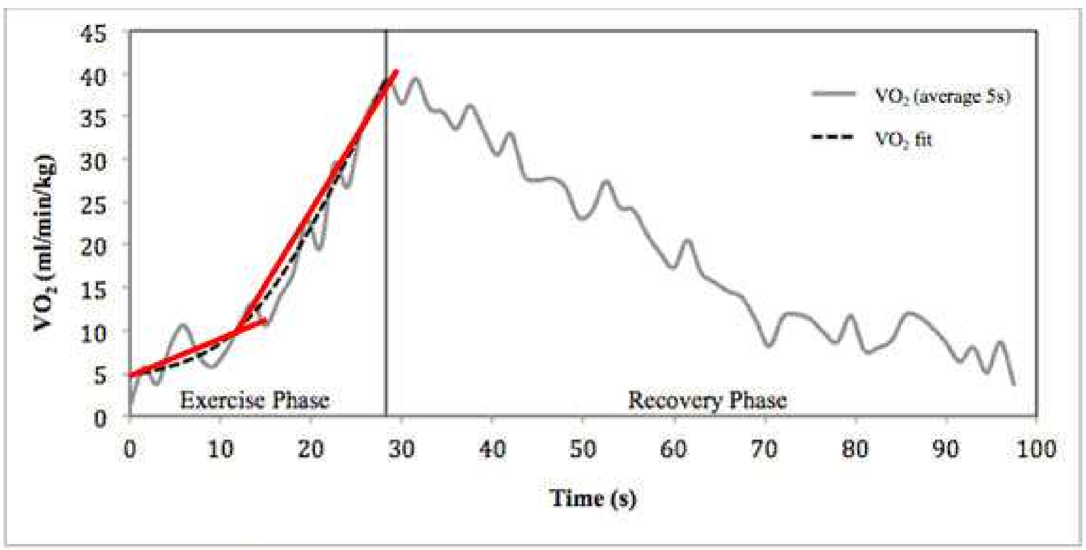

Figure 1. Example of a VO_2 to time curve during the 50 m front crawl event. The best fitting is also represented.

Despite the shortcomings of the available descriptions of energy utilization in 50-m events, one can still make some cautious interpretations of the published findings.

[11] The *SwimPro* recording system is ideal for the provision of swimmer feedback. The slow-motion, delayed recording presentation, and many other features provide resources that are too valuable to pass up. Michael Andrew's coach, Peter Andrew, and the Cherrybrook Carlile Swimming Club coaches use the system to great advantage. It is difficult to provide opportunities for swimmers to generate their own feedback about technique and skill efforts but with the *SwimPro* that is facilitated in a most effective manner. Information on the *SwimPro* is at *http://www.swimmingcam.com/*.

- Oxygen utilization appears to occur in two general stages. In the early part (up to about 40% of the task), the rate is not as steep as the latter part of the task. Using that as a guideline, this writer advocates dividing a 50-m event into two stages; i) a maximum sprint to and through the 15-m mark, and ii) from there on complete the rest of the race. The dyspnea sensation will be greater in the second stage than the first.
- There is no need to specifically train the anaerobic and aerobic mechanisms associated with the sprint. With practices emphasizing surface-swimming technique and racing skills all at maximum velocity, in time the energizing functions for those activities will have been stimulated sufficiently to produce the best and most specific energizing capacities possible for a 50-m race.

The training benefits for 50-m races will be largest when the techniques of surface swimming and racing skills are emphasized and continually refined and practiced while swimming at maximum velocity. The ceiling limit on skill development is rarely achieved and so that feature has rarely been observed.[12] As well, the thought structures that are to be used in a race-strategy also need to be practiced at race-pace intensity. Since improvements in maximum sprint-swimming performance can only occur by continually trying to swim faster, the form of USRPT needs to be changed to facilitate the greatest volume of maximum-velocity swimming possible. At all practices, training sets are performed until performance slows and cannot be recovered even with sumptuous rests between repetitions. The initial failures that indicate to stop the set are likely to be due to neural fatigue. Any more fatigue beyond neural failure will yield no benefits for a sprinter. Training has to maintain a sprinter's force-producing capacity (*a.k.a.* strength) if it is to be of any value for their performance improvement (Costill, 1998).

Programming Content

Although a 50-m race is short in distance and duration, it still contains a level of complexity that approaches that of other swimming events. The importance of how training is programmed for the 50-m race is highlighted by the need for emphases on technical perfection and psychological pre-race and race control. Practice time needs to be used as efficiently as possible given the very large increase in rest/recovery time between repetitions in a set and between training tasks.

Effective coaching will be limited in training 50-m swimmers if it is conducted alone. Since every task should be timed, it is helpful to have volunteers assist with timing. That is an opportunity to make parents feel useful and closer to the program, which contrasts to a common claim that parents are detrimental in swimming environments[13].

[12] The highest levels of skilled performance improvements are described mainly from anecdotal evidence. Master musicians still play their instruments better well into the latter years of performing (possibly 7th and 8th decades of life). Cuban cigar workers continue to improve the quality, accuracy, and number rolled per hour after 50 years of employment. The research difficulty is determining when peak skill performance has been achieved. In physical activity it is often injury before age that signals to cease participation. In swimming, outstanding performers are competing much longer and to higher ages than several decades ago. The outstanding performances of the American sprint swimmer Dara Torres (aged 42 years) at the 2008 Beijing Olympic Games provided a suggestion of swimming skill improving for as long as one intends to compete and train fully.

[13] Coaches who deride the role of parents in swimming suffer an interpersonal social inadequacy. Parents can be co-opted to perform useful functions. Those who fail to perform a prescribed function need to be told that as well as given an opportunity to correct their insufficient functioning.

Warm-up

In keeping with the USRPT recommendation that warm-ups for practices and the large majority of races be done out of the water (Rushall 2014), it is recommended that for 50-m training sessions that warm-ups also be out of the water. Some of the reasons for dry-land warm-ups are:

- They can be conducted safely anywhere, for any length of time, and can be completed at the moment the swimmer comes under the control of the coach at the poolside.
- The content of the warm-ups can be individualized and swimmer controlled.
- Dryland warm-ups are opportunities to practice race build-up strategies in sections or entirely.
- Dry-land warm-ups can be performed before in-water practice starts. That releases the full time of pool availability to be used for race-relevant technique, racing skills, and psychological training.
- There is no difference in effect between dry-land and in-water warm-ups (Romney & Nethery, 1993).

This writer recommends that warm-ups at practices consist only of pre-race strategy content. Once per week, the full race build-up routine should be practiced during the 30 minutes before the scheduled time when the pool becomes available for training. On that day, the first swim should be a time-trial to complete the full simulation of race-preparation and race-execution. At the remaining practices, the last 10 minutes of the race build-up routine should be practiced so that peak training-performances are possible from the outset. With the amount of recommended warm-up being conducted before pool availability, the amount of time available for USRPT is maximized to that of the duration of pool access.

Basic Parameters of Training Sets for 50-m Swimmers

The structure of a set. A common method of writing a USRPT set follows. A USRPT repetition set can be structured as in the example below.

Technique or Psychology Item	**Event and Stroke to be Swum**	**Repetition Distance**	**Total Interval Time (work + rest)**	Maximum Number of Repetitions (Optional)
Focus on ultra-speed of movement	50 FS	15 with dive and transition	Complete recovery or a maximum of 4 minutes	Until two failures in a row (0.2 seconds)

The first item indicates the cognitive content of each repetition. In this case it is the speed of movements in the dive, the transition, and the surface strokes that occur through 15 m. The optional *"maximum number of repetitions"* is actually a description of when the set should be terminated, not a finite number of repetitions to be executed. In this example completion is warranted if two successive swims are slower by a margin of >0.2 seconds than the previous fastest swim. That understanding subtly implies that any repetition is an opportunity to go faster than before. The training focus of discovering and adopting actions that lead to faster swimming in all 50-m relevant practice items has to pervade every practice. In one way, the coach has to exhibit as much positive enthusiasm for improvement as any swimmer. The best time of performance in the set, how many repetitions were performed successfully before the two successive failures and the technique or psychological feature used need to be recorded. Those values should serve as training targets the next time the same set is attempted. The final rest interval stipulation is necessary for practice and resource organization. In this case, for the 15-m repetitions, there is a maximum of four minutes rest between trials, which should be more than enough time for recovery. If some swimmers are found to recover satisfactorily in a shorter time (e.g., < three minutes) they should be given the opportunity to repeat swims on a shorter turn-around so that they can be exposed to a greater volume of race-relevant conditioning.

The main features of the task illustrated above are as follows.

- Develop a clear understanding of what the cognitive content of each repetition should be.
- Perform as many repetitions as possible allowing satisfactory recovery between repetitions.
- Time every swim over 15 m.
- Times should be expected to improve in the early repetitions.
- When two repetitions are more than 0.2 seconds slower than the previous fastest time, the set should be terminated. When a time is 0.1 seconds slower the difference is tolerated because the confounding variables that exist at practice make it very difficult to perform perfect replications. If one swim is more than 0.2 seconds slower than the previous time but the second repetition is fast again (i.e., it is successful) then the monitoring of slowing starts again. This is a departure from standard USRPT failure designation (i.e., two successive failures or a total of three failures to perform at the target time are the usual criteria for set termination).
- Thus, there is a range of 0.2 seconds or less of slowing that is tolerated to account for acceptable performance variability.
- The best performance of the session, the number of successful repetitions, and the cognitive content of the set should be recorded in a swimmer's log or journal.

At all times in all repetitions, coaches and swimmers should be adhering to the expectation that no stroke or skill is executed without some cognitively controlled purpose. Non-purposeful strokes are a waste of time.

Terminating participation in a set. USRPT for sprinters (a.k.a. *Sprint-USRPT*) requires a standard of performance that is oriented to performing faster. Factors are brought to swimming practices that usually do not occur at swim meets (e.g., fatigue from outside activities, accumulated stresses from previous days, lack of race-excitement, etc.). Those factors normally inhibit a swimmer's ability at practice to match the previous best time for a 50-m sprint obtained in a race or the best time produced in a practice if it is faster than the most recent race-pace. It is possible for a sprinter to be swimming fast for a practice effort but it does not quite match what was done in a *"best"* race or a faster time performed at a previous practice (usually since the last race). A decision has to be made about what is a reasonable expectation for a *"race-pace"* or its near-equivalent effort at practice.

1. If there is too much difference between the current practice and best-race/best-practice standards, then the practice application might not yield any benefit. Off-pace training does not make much sense for any USRPT activity. A time-difference of more than 0.2 seconds slower for a 15-m or 25-m effort is suggested by this writer as being too slow. There is no research to independently suggest the magnitude of that difference. Given

that sprinting is an explosive-power activity there is likely to be a need to perform several trials before a *"best practice time for that day"* is recorded. If that time is not within 0.2 seconds of the best-race/best-practice time then sprint practice should be terminated for that swimmer. If it is within the 0.2 second range, repetitions should continue.

2. Within a set, when two successive trials are more than 0.2 seconds slower than the best performance of the day, it indicates the swimmer is likely tiring and the set should be terminated. Consequently, the coach and swimmer have to assess two performance qualities for every sprint-set.

- After several repetitions, is a swimmer's truly best-effort for the day more than 0.2 seconds slower than the actual best-race/best-practice quality (for either 15-m or 25-m repetitions)? If the difference is too large then the set should be terminated. Further rest would probably help the swimmer more than if the *"slow"* set were continued.
- If the performance standard is acceptable, the set is continued. Eventually, if 15-m or 25-m set performances for two successive repetitions are greater than 0.2 seconds *slower than the best time of the day*, the set should be terminated.

Thus, two decisions are made for every sprint set at practice. They concern the day's performance standard relative to the best-race/best-practice performance level and the ability of a swimmer to maintain an agreed-upon standard for each repetition in the set for the day. In lieu of any objective research, the 0.2 seconds standard for both decisions is recommended by this writer.

An example: Question: *If my sprinter makes it within .20 seconds of her best time and then completes rep after rep and actually gets faster, should I eventually drop it down to a new time in the set or leave it as within .20 seconds of the original time? So here is what happened. I eventually told her to stop after two slower misses of .20 seconds from 11.0. Is that right?*

The swimmer's best time is 23.64 seconds for yards. She would need to be close to 11.82 seconds for the average 25-yards pace. In practice last night she did 25s with starts and recorded these times.

11.5 11.3 11.5 10.9 10.7 10.3

From then on she just kept hitting 10's for 18 repetitions until I decided to push her to stay under 11.0 seconds. Then she eventually missed two in row after a few more in the 10.0-seconds range.

Answer: *You are doing 25s with a dive which would make the first 25-m lap race-pace time considerably faster than the race average. My guess would be an expectation of at least 11.00 seconds or faster would have been acceptable from the outset.*

Your first decision is whether the swimmer is fresh enough to do valuable training. That would be within .2 seconds of best-race or best-practice time (time from a previous training session). If she meets that criterion then the set goes ahead. Using the 11.80 criterion was correct but now when you think of it with a dive it probably should have been 11.00 seconds. Had she started with a push-off, she probably would have gone slower and nearer to 11.80 seconds would have been appropriate.

The second decision is based on the best/peak time of the set for that day. When she starts to tire in the set and falls .2 seconds slower than that best-time, then you would cease the set.

I would be extremely encouraged if a swimmer could get more than 10 high-quality sprints in a set. From the times you have provided you can see the "warm-up" effect of the power ability in sprints. [It would seem that she would need to do five or six 25s as close to her race as possible to be really ready to swim fast.] In the data you provided she got down to 10.3. She should continue but when she goes more than .2 seconds slower (i.e., 10.6 or more) for two in a row you would terminate the set. At the next training session when you use this same set, the time to use to determine if she is ready for a meaningful training set would be 10.5, because the set you describe her doing was very fast.

There will come a time when in repeated sets across a week or so there is no change in best time. That is when you look for improvements in surface-swimming technique or racing-skills techniques. As well, if a swimmer had a fabulous practice and went extremely fast but then in two or three subsequent practices could not get within the .2 seconds of the "fabulous" fast time, the coach would downgrade the criterion and get the swimmer going again with full sets that hopefully will climb up to or even pass the fabulous time.

These criteria provide a constant orientation to get faster. Always look for an "edge" (an improvement). In time, swimmers should adopt that as a personal philosophy which means there would be no self-imposed limits on what they think their fastest performance would ever be.

15-m repetitions. Until recently, the shortest distance for repetition training was proposed as being 12.5 m/y. However, strongly influenced by the racing requirement for the laps of all events, that was changed to 15 meters. Race-ready pools should have the 15 m resurfacing mark on the lane lines and sides of the pool. The 15-m rule applies to swimming after a start and all turns. A swimmer’s head must break the surface at a distance no greater than 15 meters in freestyle, backstroke, and butterfly as well as individual medley and relay events.

When training for 50-m events, the 15-m mark is particularly important. By the time it is reached, swimmers should be performing at peak velocity. In a single-lap long-course race, the 15 m will consist of the racing skills of the dive and transition underwater swimming and at the end surface swimming. Depending upon the competence of the swimmer for progressing underwater, the amount of surface swimming will vary between swimmers.

A dive in a senior male swimmer attains a velocity in the region of 4 m/s. The double-leg kicking performed in the transition phase has the potential to use that dive's high entry-velocity so that slowing is retarded. In a sprint freestyle race, few swimmers can perform surface swimming at a velocity greater than 2 m/s. The transition phase duration depends upon the double-leg kicking proficiency of a swimmer. As was explained in Section 3 of this manual, swimmers should be tested to determine the velocities of surface swimming and double-leg kicking relevant to each other. Good kickers should be encouraged to remain underwater longer than those who do not kick well. Even for swimmers whose kicking velocity is slower than surface-swimming velocity, some kicking should be performed because the swimmer will be negatively accelerating from ~4 m/s to ~2 m/s. The changeover from transition to surface swimming needs to be determined. A simple test is to time a swimmer's progress to 15 m under several conditions. Those conditions require a standard dive to be executed on all trials which are timed from the start signal.

- Trial 1: Long low flat dive followed by four kicks and surface swim through the 15 m mark.
- Trial 2: Long low flat dive followed by six kicks and surface swim through the 15 m mark.

- Trial 3: Long low flat dive followed by eight kicks and surface swim through the 15 m mark.
- Trial 4: Long low flat dive followed by 10 kicks and surface swim through the 15 m mark.
- Trial 5: Long low flat dive followed by 12 kicks and surface swim through the 15 m mark.
- If necessary, more trials increasing the number of kicks by two per trial can be assessed.

The times for all trials should be compared. The trials should be repeated in different orders on a number of days. The most frequent best-time trial should be determined. If there is no obvious difference then the swimmer should be allowed to choose that which feels the best and is most comfortable.

Dive-transition-swim repetitions as fast as possible over 15 m should be very frequently performed. When performance times appear to be stable between practice sessions, the racing skill elements should be instructed so that they attain a high level of repeatable efficiency. Once the skills are established, the speed of all movements in each of the three phases once again should be emphasized for a considerable time. The speed factor in movement is the first and last element capacity to be coached. As with any good coaching program, periodic technique and racing skill analyses should be performed to correct inefficiencies that might be developing or to discover if one of the phases has regressed in execution standard. In coaching 50-m swimmers, the search for improvements should always be obvious and even to the extent of being a mild obsession.

- As with all repetition distances, in 50-m training generous recovery periods should be provided although it would be an unnecessary waste of expensive pool and coaching time to make them excessive. As close as possible, every dive-15-m repetition should be a race simulation with the added feature of focusing on one or more technical factors that could improve performance.
- As many repetitions as possible should be completed. The termination of a set of repetitions should occur when a swimmer begins to slow. The general criterion for termination of a set is when two consecutive trials are slower by >0.2 seconds than the fastest time recorded in the set. If there is a reason for a slow time that is unrelated to the skill factors of the 15-m task (e.g., a foot slips on the block platform; goggles come off on entry, etc.), it should be ignored.

A 15-m repetition should be aimed at improving as much as possible in the first 15 m of the event. Occasionally, it might be advisable to take one of the elements and practice it alone. Perhaps an emphasis on part of the skill needs to be practiced. That is useful if it is as close to how the skill should be done in a race and not some unrelated drill. Once improvement in the skill is evident in the isolated practice, it should then be incorporated into the 15-m repetition. It is usual that when moving from an isolated skill (e.g., the dive) to a complex skill sequence (e.g., the dive, transition, surface swimming to 15 m) that the skill still be worked on in the new more complex task-setting.

The number of repetitions in a 15-m set will be determined by how many are completed before the termination criterion (>0.2 seconds slower for two consecutive trials) is met.

25-m/y repetitions. The 25 m/y distance is the backbone of 50-m training. With complete recovery between repetitions, a lot of distance at 50-m race-intensity can be covered before neural fatigue begins to influence the quality of performance. As usual, every swim should be timed and the set of activities completed when two successive repetitions are slower than the best by >0.2 seconds.

The content of 25-m/y repetitions can vary greatly. Some possibilities are:

- Dive, transition, surface swimming, finish approach, and finish (a *"dive-25"*). This is how a *timed-25* should be swum. All facets of this task are race-relevant.
- Push-off, double-leg kick to 12.5 mark, surface swim, finish approach, finish. The early part of this activity, the push-off, is not race-specific.
- Push-off, swim as fast as possible, finish approach, finish. The early part of the activity is not race-specific.

As much of every 25-m/y repetition as possible should be race-relevant.

Something that is overlooked frequently in 50-m training is the number of repetitions performed on each task. Once one of the above examples is completed and timed, further repetitions should be swum until performance falls away by >0.2 seconds. Nothing valuable is gained from performing only one or a few repetitions. There just is insufficient practice to produce learning and/or a training effect. Insufficient repetitions in a swimming task are simply a waste of time.

50-m/y repetitions. Swimming as fast as possible over 50 m/y is not recommended for 50-m race training. What is included in a 50-m/y repetition is 25 m/y build-up or slow-down swimming and 25 m/y at 50-m intensity.

The content of 50-m/y repetitions can vary greatly. Some possibilities for a 25 m/y pool are:

- 12.5 m/y build, 7.5 m/y surface swimming, approach the turn, turn, transition off the wall, sprint to 12.5 m/y mark, then gradually slow down for the remainder of the second lap. This is one way that turns can be practiced at race-pace. The drawback is that times are difficult to record for this exercise. If the activity is for turn practice, then underwater videos of the turn approach, execution, and transition off the wall would facilitate timing a defined start and finish of the turn by counting the number of video frames it takes to complete the delimited turn.
- Build to the turn zone. Execute a race-pace turn approach, turn, transition/break-out, swim to 10 m from the next wall, finish approach, and finish. This is a difficult task to time and it does produce significant fatigue because the work in the repetition is greater than 25 meters/yards. Performing a set of repetitions of this work could be the most difficult and fatiguing activity in a training session.
- Since 50-m repetitions contain approximately 50% of the distance at irrelevant velocities, doing them very often has to be strongly questioned. If a coach can innovate 50-m repetitions that can include more skill elements than exampled here so that the distance swum yields more race-relevant activity then it should be considered for inclusion in a training session.

Training for 100-m/y races. There is a growing belief among USRPT coaches that training for 100-m races somehow improves 50-m races in the same stroke. There are just too many instances of 100-200 m/y swimmers also improving in 50-m races without having done specialized training for the sprint. One could hypothesize why such a relationship could occur.

The late George Haines opined that to do well in a favored race, a swimmer would have to train and compete seriously in the longer-distance event above the favored race. In 1992, the US champion swimmer Matt Biondi, was swimming in the Barcelona Olympic final of the 100 m. Since the 1988 Olympics, Biondi had given away training for events longer than 100 m. In the Barcelona final, Biondi was first with 10 m to go. He finished fourth in the race. George Haines thought that the reason for the other three swimmers swimming over Biondi was that Biondi did not have the stamina to sustain the final 10 m of the final. The explanation suggested that had Biondi also trained and raced 200 m, he would have had developed enough stamina to maintain his swimming velocity in the Barcelona final enabling him to win the race.

While no research is available to verify the principle of training *one distance up* to assist performing in a favored event, this writer recommends that it be followed until contrary evidence is available from some scientific work.

The standard USRPT training item is to swim at 100-m race-pace over 25-m/y repetitions with 15 seconds of between-repetitions rest. The set is terminated when the race-pace cannot be maintained on two successive repetitions or a total of three failures occurs. This set is applicable to all 100-m events in the four competitive strokes. The number of successful repetitions completed before termination, the number of successes before the first failure, the target race-pace time, and the cognitive content for the set should be recorded. Not only should improvements in 100-m events be analyzed but so should the 50-m performances in the same stroke.

Individual skill practices. Each racing skill and technique feature could be practiced individually early in the learning or modification process. The development of a technical feature is not complete until the altered element is integrated into the complex sequence as it occurs in a race. For example, surface swimming is only initiated in a race from an already moving technical skill (the double-leg kicking transition stages after a dive or short-course turn). Consequently, surface swimming after a push-off would not be initiated in the same race-specific manner that should be a criterion for inclusion in a training program. Surface swimming should only be practiced after the determined amount or more of beneficial double-leg kicking. A push-off with one or two kicks would be an unsatisfactory practice item initiation.

Individual skill practices should only be performed in the early stages of learning or alteration of the skill. They should not be used for training. What should be trained are the skills in the simulations of ace sections. An overemphasis on isolated skill practices could have a negative effect on race performance.

Formats. It is assumed that the total practice time in the pool is at least two hours. All skills and repetitions should be performed as many times or as much as possible before neural fatigue alters performance. Only as-fast-as-possible repetitions on a training day should be sustained and used. No benefit(s) would be derived from swimming progressively slower repetitions in a fatigued state. Learning and skill modifications and increasing movement velocity are suppressed by fatigue.

Coaches need to be innovative and yet cautious when devising USRPT sets for sprinters. For example, assume there is a need for swimmers to improve some skill element in double-leg kicking. That form of kicking in a race only begins from a very high velocity movement (e.g., a dive at ~4 m/s or a wall push-off on a turn at ~3 m/s) and finishes with surface swimming at maximum velocity. To do a set of 25-m repetitions of double-leg kicking would not be beneficial. First, over that distance kicking velocity is likely to be sub-maximal. Second, both the commencement and finish of the skill is not race-specific, that is, they are irrelevant for 50-m sprinting. One possible activity to be practiced in a set would involve a dive, double-leg kicking up to the 15-m mark and then surface swimming to the wall practicing a finish touch. All elements replicate 50-m race features with the exception of the finish touch which is not preceded by the finish approach. One could add that in as well to make the total activity race-specific in terms of racing skills and surface swimming technique.

If the above example was changed to start with a wall push-off (non-specific activity) with transition double-leg kicking to the 15-m mark to surface swimming, followed by a finish-approach and finish touch then most of the activity would be race-specific. The longer than any length of race-kicking could constitute a suitable training overload for the kicking skill. That would be acceptable for an activity that was designed to improve double-leg kicking.

The above example should be compared to sprinting push-off 25s as fast as possible. In a race, surface swimming never starts with a push-off and always finishes with a turn-approach or a finish-approach. Solely swimming as a repetition would be acceptable if it is a practice of some surface-swimming technique feature. It is designed to learn a movement feature which would at a later stage be incorporated into a more complex race or part-race simulation. Technique or skill elements in their early stages of learning or modification are acceptably practiced as the lone element in a repetition. However, at some stage what is learned in a specific practice aimed at altering some racing skill or surface swimming element will have to be transferred into race-specific activity sequences and part-race simulations.

When devising training repetitions, a coach has to decide if it will be a skill/technique learning activity, a combination of the new learning with an already established race-segment, or an introduction into the part of a race where the element would occur at race-training velocity (a part-simulation). Specific skill change practices should be time-consuming so that many repetitions are experienced. Race-simulation repetitions should occur for approximately 50% or more of a practice. When approaching an important race, race simulations should consist of 100% simulation repetitions because of the *nothing new at competitions* principle. A tentative rule (no research has been conducted to verify this rule) is to not introduce skill or technique changes in the four-week period before a major championship. If something was introduced closer to a championship insufficient practices would likely occur to justify the element being employed in the stressful championship events.

The following are recommended.

- Every practice should be preceded by the total or the last portion of the race build-up strategy as the warm-up activity.
- 15-m practices should be included in every training session.
- The majority of repetitions should be over 25-m every training session.
- A period of high repetitions of at least one racing-skill should be included in every training session and often as part of a 25-m repetition set.
- A surface-swimming technique feature should be practiced usually in association with all repetition distances.
- Some race-strategy item or technique feature should be included as the cognitive component of an appropriate repetition set.

- 100-m training should be conducted in the standard USRPT format at least three times per week when training once a day, or every alternate session when training more than once per day on several days.

The above suggestions are not exhaustive because it is the stress response of the swimmer to the training load that will determine when adequate practices can be experienced. Practices should include the possibility of improving in at least one training item within the session. Preferably, more than one item should be improved. To facilitate those improvements, a racing skill or surface swimming technique feature should not be practiced in consecutive sessions. Allowing 24 to 48 hours recovery from a training stimulus effect is a conservative approach for encouraging improvements in elements of 50-m racing.

Records of each session's accomplishments and performance levels should be kept so that improvements at practice in each facet of a race can be documented. Practice improvements should be incorporated into the race strategy and should be evident in the next race.

The physical work of 50-m USRPT is quite limited. The race is short, has definite surface-swimming technique features and racing skills that occur in a set order in a race. Some coaches would worry unnecessarily about this limited scope of work as having little variety. However, given the richness of the cognitive activities associated with technique and racing skills, variety is accommodated through the mental work of sprinting, not the physical work.

Physiological improvements are limited by the genetic structure of a swimmer. Fitness for a 50-m race should be attained relatively quickly (certainly by eight weeks of consistent swimming). Each change in a skill or technique element will require further training so that the energy resources for the new performance can be honed to the highest level of efficiency. While fitness adjustments occur in concert with skill and technique adjustments, in the big picture of race-fitness they are only minor and will be stimulated by sufficient repetitions of the skill elements. Perhaps the biggest adjustment of a coach for adequately coaching 50-m racers is the number of repetitions of skill elements. Movement skills take longer and more training to develop than the overall fitness for the event in which they will be performed. It will be a difficult task for some coaches who believe that swimming fitness improves all year when all-year training is followed. Conditioning effects from training are achieved in a shorter period of time than motor skill changes/developments. In the USRPT complex model of swimming coaching, skill coaching is the major responsibility for assisting swimmers to achieve performance improvements on a year-round basis.

CLOSURE

Because of differences between training approaches to 50-m racing and all other events, 50-m training cannot occur adequately when it is embedded in a *"normal"* USRPT program. Specific experiences and coaching are needed. An obvious outcome of this realization is that a best situation would be to provide a specialist sprint program with its own coach. If such situations occur, they are rare.

It is wrong to assume that 50-m sprinting is trained adequately while working toward 100-m events. For all strokes, specialized training is needed to produce the best 50-m performances of which swimmers are capable. For world-championships, the selection procedure of naming 100-m event winners in the strokes other than freestyle to compete in 50-m events can be faulted. Training for 100s does not adequately prepare swimmers for 50s. In this manual it has been advised that there appears to be some benefit from USRPT for 100-m events that could carry-over to 50-m racing, but that is not equivalent to the specialized experiences that could be provided.

While this manual has only talked of training for 50-m events, 50s do not have to be the only event in which sprint swimmers are interested. The USRPT program justifies and advocates training for different events as uniquely different experiences. Sprint training will consume a considerable amount of practice time before a swimmer's event-specific neural fatigue (i.e., performance-standard failure) in the last planned experience signals to halt that session's sprint work. In the remaining time, other events and/or strokes could be practiced.

There are some significant features of sprint training that set it apart from other-event training. Most involve a change in emphasis on standard/normal USRPT parameters. Those changes could well be of benefit to non-50-m event training if they were applied.

USRPT requires sprint training to be intense.

Constant Motivation to Improve

Swimmer's responses should always be striving for an improved performance at every opportunity. When practice improvements are not forth coming, a coach is left with three alternatives: i) add a new element to the skill repertoire of the swimmer, ii) add a technique feature to a swimmer's surface swimming form, or iii) refine further to a higher level of precision existing skills and technique features. To recognize what might be done, it is necessary that continual (daily?) video analyses of the technique and skill executions be conducted. The tools to do this effectively exist. The difficulty is that coaches rarely analyze swimmer's underwater work during long periods of training. The effectiveness of video feedback on skill learning has been documented in the motor learning and pedagogical literature. The external visual imagery prompted by viewing a video is effective in the early stages of skill learning and/or for changing major motion features (Hardy & Callow, 1999; Schwarz & Hawkins, 1970; Stancil, 2003). Video analysis serves to limit the variability of brain function in learning situations. Learning is facilitated (Winstein, Grafton, & Pohl, 1997).

While video analysis systems are available[14], their maximum effect will only be gained at practices if a specialist videographer is available. That is a role that interested parents could play.

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[14] This writer recommends the *SwimPro* recording system *http://www.swimmingcam.com/*.

Using video-analysis swimmer meetings and coach-alone assessment sessions increases the amount of work that a coach would have to do as a professional responsibility. On the other hand, the benefits derived by swimmers justify the activities.

The simple impact of the technique and skills emphases of USRPT and in particular for sprinters, is that coaches have to expand their knowledge base of what is important for improving swimmers to levels not yet achieved and implementing that knowledge at practices in sound and meaningful ways. This is not possible in a traditional swim coaching program where the athletes perform reasonably long interval sets, extensive warm-ups and warm-downs, and the coach calls out times as repetitions are completed. In such situations, performance stagnation occurs quickly once growth stops. It is unfortunate that the effect of growth in pre-pubescent and adolescent swimmers is sufficiently strong that it promotes some performance improvements in programs that really are not performance-improvement capable. The inability of many senior swimmers[15] to improve their performances can be construed as strictly as a suggestion of a stagnation program which, at best, introduces novel irrelevant training experiences usually to keep swimmers interested in the sport. Albert Einstein spoke of behavioral inertia which could apply to many swimming training situations; "*The definition of insanity is doing things in exactly the same way and expecting a different result.*" In the manner in which USRPT is promoted and described, a high level of coaching industry and specific expertise are required of coaches. Such knowledge is not of a self-revelation nature (e.g., superstition) but of rationalization using the extensive findings of human movement science to constantly upgrade knowledge and elevate the standard of coaching.

Directed Thought Content

The requirement of swimmers to always have practice and competition strokes accompanied by specific task-relevant and emotional thought-content is difficult to develop. Unfortunately, it is the norm that when swimmers complete repetitions and intervals in traditional training settings their thought content is rarely on swimming. Concentration on technique is a rarity (Personal communication, Dr. Rod Havriluk – June 4, 2015).

A number of studies in this writer's laboratories have produced performance changes in athletes when they were directed to concentrate on task-associated thoughts (Chorkawy, 1982; Crossman, 1977; Ford, 1982). The usual paradigm for such studies was an intrasubject research design comparing training performances using three sets of thoughts: i) normal training-thinking, ii) distracted thinking (e.g., singing songs, planning homework, etc.), and iii) task-relevant thinking. Generally, performances were enhanced by task-relevant thought content whereas there seldom were differences between the other two conditions. The implication of the research program was that training responses and effects are far from optimal because of the non-specific thought content habitually engaged. Exhibit 5 is an example of the performances at practices of a swimmer who reacted very well to task-specific thinking in the daily experimental trial. While the illustrated performance was not a sprint task but a 400-m time-trial, the central thesis that task-specific thought content during repetitions at training results in performance elevations was supported.

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[15] Senior swimmers have achieved growth-maturity. Normally, that occurs in females from late 14 years to late 17 years of age. In males, it is normally between 17 and 19 years of age. Occasionally, some individuals fall outside of those age ranges.

The effects of directed-thought content on performance are not immediate (Selkirk, 1980). It takes time for an athlete to learn to focus continually on particular matter, some individualization is necessary (i.e., swimmers listen to the coach and then adapt the content to their own thought structures), and performance changes are revealed some time after the introduction of emphasized specific-thinking activity.

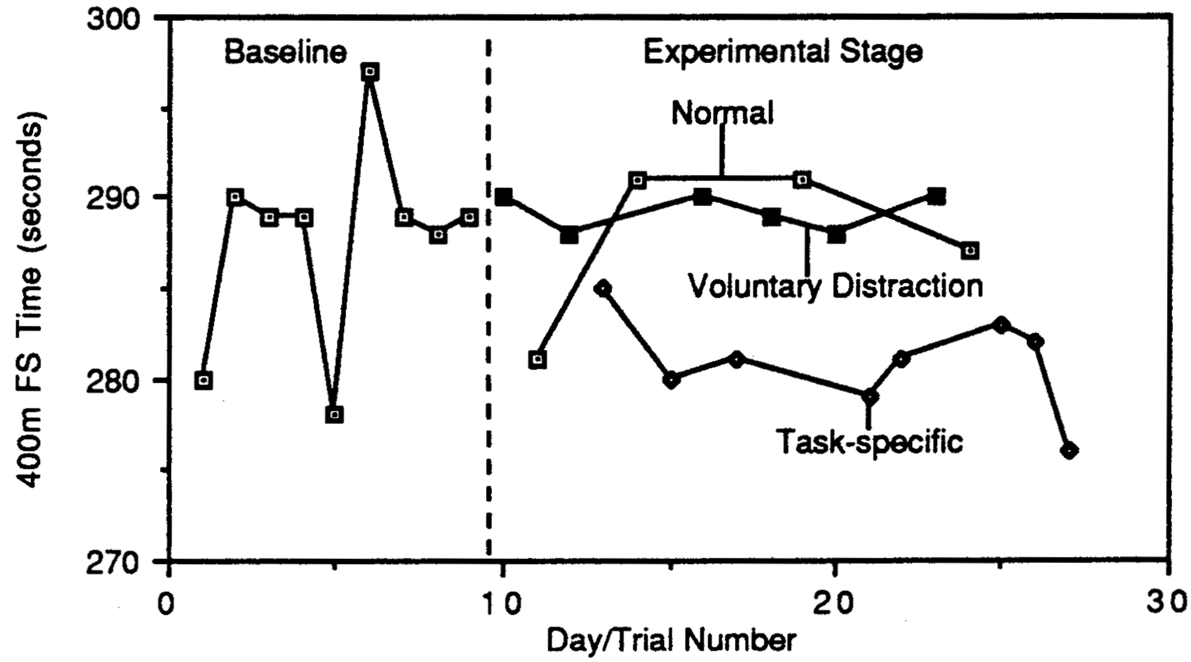

Exhibit 5. Daily 400-m FS test-trials of an 11 year-old female swimmer under three different thought orientations. Task-specific thinking eventually was vastly superior to normal and contrived-distraction conditions (after Chorkawy, 1982).

Sprinter's Character

Once a swimmer's understanding of the required intensity of behavior for 50-m USRPT is grasped, groups of such individuals will have a different character to a general swimming group, all of whom would be training for a variety of competitive events. The sprinter's personality in a USRPT setting is very focused on task-application, explosive skill and stroke executions, and a deep interest in feedback after each training item. A sprinter's group would not function well with members who are not driven to achieve or who are not as conscientious about details as are the best performers. Average or moderate interest in what is required just will not satisfy what is needed and will be detrimental to the swimmers who attempt to apply themselves fully to all 50-m related tasks. Consequently, when a group of sprinters is formed, initially membership should be temporary to allow those who are distinctively focused on their training to show themselves. Those who continue on with a less-than-driven attitude should be returned to the general training squad.

There are some swimmers who have little endurance capability but have a capacity to move fast. Such swimmers fatigue rapidly within common training sets and often do not recover between normal training sessions adequately. A common name for such individuals is *"drop-dead* *sprinter"*. Those swimmers should do well in a USRPT 50-m training group because the performance focus is on quality of response rather than aerobic-distance training. The USRPT procedure of terminating a swimmer's involvement in a training set when *neural fatigue* has been evidenced, allows any training experience to be individualized to all swimmers' peculiar needs. When a sprint-group member ceases working on a set of tasks, they should engage in a dry-land recovery routine that does not interfere with or distract other swimmers in the pool.

Sprinters also should show different responses to the training stress of constantly performing maximally. After a particularly heavy training load, more than 24 hours might be needed for an individual to recover to the point where at the next training session performances can improve further. If a sprint-group member displays performances that progressively worsen as the week unfolds, then it is reasonable to conclude that between-sessions recovery is insufficient. Rather than participating in a reduced workload at practice, which might involve a more than usual amount of irrelevant swimming, tired sprinters should not attend practice at all. If the correct state of mind and motivation to perform is to be developed, sprinters should only expect to improve in 50-m performance features at practices. Hypothetical excuses should not be made for less than desirable responses when a swimmer tries his/her hardest.

The need for sprinters to follow strict behavioral guidelines at practices and swim meets is part of their training for developing a level of focus and self-discipline that will transfer to their approach to competitions and races. Within a group of sprinters, there is likely to be gender-discrimination. A coach of a both-sexes squad would have to be adept at switching between appropriate handling and interaction behaviors for each gender.

Standard-USRPT Modifications

The maximum intense training responses expected of 50-m swimmers does require alterations in some Standard-USRPT parameters. Between-repetitions and sets should be close to complete so that a sufficient volume of technique features and racing skills trials can be performed to produce a behavior change. The organization of the training group into work and rest cycles might require some innovation in a coach's way of thinking. Generally, in motivated athletes it is acceptable to heed the swimmer's opinion as to when recovery has occurred. However, there is an upper limit which needs to be applied as a pool rule to keep practices organized. Recoveries between: i) 15-m trials are likely to be from 3-4 minutes, ii) 25-m trials require more time and 4-5 minutes would be the limit; and iii) in 100-m training sets where 25s are repeated, rests should be in the vicinity of 15 seconds (see Rushall, 2015e). Even with luxurious recovery, because of the performance standard that is encouraged, performances eventually will begin to slow. A reduction in performance in the vicinity of >0.2 seconds for 15-m and 25-m repetitions on two successive occasions is a reasonable point to terminate a swimmer's participation in an ongoing set. Recovery should commence immediately out of the water.

Sprint training will only be as effective as the recovery levels achieved between training tasks and sessions. Some USRPT programs assess the status of all swimmers when they enter the training environment by having them complete a short set of questions. Those who are particularly negative should be encouraged not to train and return home for more rest. When the responses are not definitive, the early standard of participation in the initial training sets should be assessed. If they are unsatisfactory, the swimmer(s) should be encouraged to go home. If that cannot occur immediately, the swimmer should participate in non-swimming activities so that further needed recovery is experienced. There is no value to the swimmer or coach to attempt training tasks that cannot be completed to the standard that is required for effective training. Good sprinting can only occur in rested swimmers.

Sprint-USRPT Effects

Fitts, Costill, and Gardetto (1989) showed that normal/tolerable swimming training does not alter the force-velocity relation in either Type I or II fibers. Intensified training reduces the contractile velocity of Type II fibers further. The harder a swimmer trains, the poorer will become sprint-swimming performances. Tapering should produce a recovery from depressed sprinting performances. The susceptibility of the Type II fibers to an individual swimmer's stress tolerance will determine when sprinting can occur to satisfactory levels. The *dulling-effect* on sprinting capability of traditional training is one reason why sprint-training should occur independently of most other swimmers in a program. USRPT allows a coach and swimmers to adjust training workloads to avoid excessive fatigue (Rushall, 2014c, 2014d) which should allow fast sprinting to occur at any time. However, it is the expectations of 50-m sprinters that require a separate training group. Not only are the types of work and full recovery cycles different to Standard-USRPT training but so are the performance expectations. Standard-USRPT usually encourages swimmers to swim longer at a set race-pace to derive a beneficial training effect. Sprint-USRPT encourages swimmer to swim faster over a set distance to derive a beneficial training effect. Because of that, 50-m sprinters should be able to swim fast or their fastest at any time in the year. Sprint-USRPT aims to prevent a swimmer's Type II fibers from degrading due to excessive fatigue. Fast swimming races should always be possible much as fast races are possible at any time in serious sprint track athletes participating in the IAAF Diamond League.

Unfortunately, in the swimming equivalent of the IAAF Diamond League, the FINA World Cup circuit, sprinters rarely approach world-class times ostensibly because their sprint work is embedded in sprint-dulling traditional training. Standard-USRPT trained swimmers will sprint better. Sprint-USRPT swimmers should always swim fastest of all on the vast majority of occasions.

Land-training

There have been a considerable number of authors who choose to ignore publications that show that traditional strength training in real-life circumstances is of no benefit to swimming performances. That is not an original thought for it agrees with Costill's (1998) considered finding that; *"You can gain strength by swimming. If you want to overload the muscle then do sprint swimming"*. Strength/land training is a false avenue for swimmer improvement (Bulgakova, Vorontsov, & Fomichenko, 1987; Breed, Young, & McElroy, 2000; Costill *et al.*, 1983; Crowe *et al.*, 1999; Tanaka *et al.*, 1993). There still is a sport-wide emphasis on developing *"strength"* in swimmers, despite its irrelevance. Occasionally, a report of the value of common strength training emerges (e.g., Hsu, Hsu, & Hsieh, 1997).

The intensity of Sprint-USRPT and most likely all USRPT swimming, will improve muscle hypertrophy and contraction speed (Losey *et al.*, 2013). To set the record straight, this writer has a unique form of land-training associated with his performance psychology practice called *Psychophysical Training* that trains swimming-specific movement velocity. It is touted as being very successful for elevating swimming performances. Being a proprietary product it is not available to the public.

The features of surface-swimming technique, technical aspects of racing skills, and the scope of performance psychology are also appropriate for 100-m swimmers. Only the conditioning features are different with the intensity of work being race-pace and the rest periods in 25-m repetition work being ~15 seconds. Some of the 50-m conditioning work could be quite beneficial for 100-m swimmers. A major difference for conditioning 100-m swimmers would be that they would have to train and race up one distance (200 m).

This manual has promoted a subset division within USRPT training prescriptions. Standard-USRPT and Sprint-USRPT in order of preference, require concentrated emphases on i) surface-swimming techniques, ii) the techniques of racing skills, iii) the psychological development of pre-race and race-strategies, and iv) conditioning in the ultra-short training format. It is only in the last factor that differences in training execution occur. They warrant a subset designation for Sprint-USRPT. It is hoped that this manual has exposed the factors that are necessary for sprint swimming. So much has been discussed that reader's should be stimulated to think that compared to what swimmers do now, what would be possible if they were trained with a full program of Sprint-USRPT?

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