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WARMING-UP IN USRPT

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Research assessing the content, various forms, and effects of warm-ups in swimming is sparse. Consequently, the content of swimming warm-ups has relied upon unverified activities to which a variety of beneficial effects have been attributed. The limited research does give some support to aspects of a warm-up although more studies would have been preferable.

Research

The effects of in-pool warm-ups¹ lasted for up to 10 minutes but not 45 minutes (Zochowski, Johnson, & Sleivern, 2007) and up to 20 minutes but also not for 45 minutes (West et al., 2012). Therefore, beneficial pool warm-up effects are short-lived. If it is not possible to warm-up in a pool within 20 minutes of a race, an alternative form of warm-up needs to be devised and practiced.

Some activities for in-pool warm-ups have been evaluated. An historically important study was conducted by Carlile (1956). It was shown that the passive activity of tolerating a hot shower for as long as possible prior to performing a maximal 55-yard swim produced improved performances in all subjects significantly more than in a control group (no hot showers). A passive warm-up is possible if swimmers have the time and opportunity to fully engage the activity.

Most studies have followed active warm-ups, that is, the changes that occur are provoked by activities. Robergs et al. (1990) evaluated the effects of a warm-up of 400 m crawl at 82% VO_{2max} , 400 m kicking at 45% VO_{2max} , and 3 x 50 m at 111% VO_{2max} on 200 m freestyle swims. Physiological and performance benefits resulted.

Houmard et al. (1991) assessed the effects of a) no warm-up, (b) a mild-intensity 1,500 yard swim, (c) intensity-specific swimming (4 x 50 yards; 1 minute rest), and (d) a combination of the b and c conditions on a 440 yard swim, which was performed five minutes after the experimental warm-up. It was found that the mild-intensity long-duration swim (condition b) was the most effective performance improvement condition. When the distance was reduced to 1,200 yards

¹ The studies in this section failed to detail what the warm-up activities were. That poses a problem when considering research. Not only is there a need for individualizing warm-up activities to satisfy swimmers' needs, there is a wide range of activities that are possible and all have their own specific effects and/or non-effects. The dearth of exactness in reporting, renders many studies relatively unimportant except in features that are already known albeit having been verified in other sports. For example, in the instances cited above it is reasonable to assert that any benefits from in-pool warm-ups for ensuing race performances dissipate within 20 minutes.

and followed by the intensity-specific condition, a similar performance benefit was demonstrated. Intensity-specific work alone may not be beneficial but when used in conjunction with a shorter mild-intensity swim was just as effective. There may be reasons other than for warm-up purposes that intensity-specific activities might satisfy.

Romney and Nethery (1993) evaluated the effects of 15 minutes of swimming (mixed distance and sprint work), dry-land activities, and no-activity on 100-yard freestyle performances conducted three minutes after completion of the experimental manipulations. Both activity conditions had positive effects on sprint performance. This study promoted the possibility of dryland activities being as effective as in-pool activities when preparing for races.

Whitehead et al. (2012) had swimmers perform static or dynamic stretching bouts followed by a "typical swimming warm-up" (~20 minutes). Five minutes after the swimming activity, a 50 m time-trial was performed. There were no significant differences between the experiences for either half of or the total 50 m swim. It is possible that the swimming activities masked any difference caused by the two stretching activities if indeed any difference existed.

The references above had the criterion swimming activities occur within 15 minutes of completion of the warm-up, the duration that is recommended for any vigorous activity (Jenkins, 2005). It would seem that researchers assumed that an in-water warm-up was a necessary aspect for swimming facilitation despite the frequent practical reality being an inability to perform in-water activities in close proximity to a race.

Warm-ups consisting of heavy or severe activities should be limited so they do not tax the anaerobic capacity and compromise the ensuing performance (Pringle et al., 2009). Intensity might be important for potentiating a performance but it should not be excessive.

Most research has focused on physiological factors and actions. A great part of competition preparation is psychological which in turn modifies the physiological cost of a competitive performance (Noakes, 2012). However, a few intriguing activities have been researched that govern the whole warm-up but mostly between the end of warm-up and the start of a race.

Felix et al. (1997) looked at a 10-minute post-warm-up period and had swimmers participate in swimming, rowing, and passive rest. Active recovery, regardless of the exercise mode, preserved lower lactate levels and performance capabilities, while passive rest did not. Kocjan et al. (2009) assessed pre-cooling with an ice-vest prior to and during warm-up. Core temperature was significantly decreased and distance-swimming performance was improved. Heat build-up is not a problem in temperature controlled water. However, in the first half of the 2000s, Speedo produced a total-body suit that resembled a heavy ski-suit. While it was commonly worn, it was only in distance events where heat accumulation occurred in some swimmers. The most notable elite swimmer was Grant Hackett of Australia who would immediately remove the top part of the suit upon completing an important 1,500 m race. His tell-tale pink skin indicated a level of heat stress. Since full-body suits no longer are permitted, heat build-up does not appear to be a problem except in very hot water². One has to question why lowered central body temperatures would facilitate performance improvements in relatively short-distance swimming events. More research is required to fully assess any benefits from wearing ice-vests in the pre-competition period across all swimming events.

² As occurred in the middle-East in a World Open Water Championship to the American swimmer the late Fran Crippen.

There are two procedures that are attracting attention in the research literature and are likely to be incorporated into warm-up regimes in the future. The first is "post-activation potentiation" (PAP). *"PAP is a phenomenon where the contractile history of skeletal muscle can serve to increase the muscle's ability to generate force and power. Studies have shown that heavy resistance exercise can serve to potentiate power production for contractile activities of less than 10 seconds duration"* (Harris, Moore, et al, 2006). Performance improvements have been shown in shot-putting (Bellar, et al, 2008; Harris, Kipp, et al., 2011), vertical jump (Batista, Tricoli, & Ugrinowitsch, 2006), and in events up to 30 seconds duration (Harris, Moore, et al., 2006). PAP seems to be relevant for the dive aspect of swimming races and 50-m events. Appropriate activities for swimming that elicit the PAP response need to be determined through research. In the near future it should be expected that a series of general highly-exertional exercises close to the beginning of a race will be a standard race build-up procedure.

The second procedure involves rinsing a carbohydrate solution in the mouth rather than consuming the supplement during exercise. It has been shown to improve performance in tasks of ~45-60 minutes duration when it has been used at various times during the extended exercise. The improved performances have been associated with reduced perceived exertion, activation of reward centers in the brain, and/or increased cortical excitability. Increased activity within the motor cortex and regions involved in reward processing suggest a neural basis for performance enhancements (Mauger et al., 2012). The performance-enhancement effect of carbohydrate rinsing is immediate. It is likely that oral energy receptors may be involved in direct stimulation of motor output regulation (Grant et al., 2012). For pool-swimming events, the swirling of carbohydrate in the mouth (e.g., glucose candies) in the minute before starting a high-intensity performance, such as a swimming race, should enhance the performance that follows. It is likely that this simple activity will become a valuable part of a race build-up routine.

Physiological Demands

On a competition day and close to races, the major portion of activities is of a psychological nature. Rushall (1995) developed a swimmer-friendly manual to assist swimmers to learn to use complete competition preparation strategies and skills. A companion manual to the 1995 swimmer's manual involving mental exercises that can be used for elements of pre-competition and competition activities was also produced by Rushall (Fourth edition, 2003). The physiological requirements of competition preparation are quite simple and cover three factors.

1. The central core and deep muscle temperatures need to be increased to at least 39°C. At that temperature, body fluids are less viscous and so can be used freely in the body's task of maintaining a safe metabolism. The role of lubricating body-structure movements is also enhanced with increased temperature. As well as body fluids, the body's soft and semi-soft structures are more pliable and accommodate movements with less energy demand. Movements are more efficient when the physical demand of tasks is lowered by better fluid flow and improved structure pliability.

The level of raised temperature should be such that a light sweat is evidenced on a swimmer's forehead, upper lip, and/or back of the hands. This is normally achieved with a deep muscle temperature rise of 2°C. A warming effect of that magnitude should produce i) more rapid and complete dissociation of oxygen from hemoglobin and myoglobin; ii) acceleration of metabolic rate leading to more efficient use of energy substrates; iii) decreases of muscle viscosity leading to an improvement in the mechanical efficiency of muscular contractions; iv) greater speed and force of muscular contractions; v) more rapid redirection of blood flow to working skeletal muscles and away from the

viscera at the start of exercise (a result of vasodilation); vi) improvement in delivery of energy substrates and removal of metabolic by-products (due to vasodilation); vii) decreased risk of injury to muscles because of higher blood saturation; and ix) improved flexibility, ability to improve flexibility, and decreased risk of injury due to increased extensibility of tendons, ligaments, and other connective tissues (Jenkins, 2005, p. 375).

The main disadvantage of increased core temperatures occurs when the rise is maintained for too long and introduces varying degrees of heat stress. As well, long heated conditions have the potential to induce unnecessary fatigue in the athlete. Thus, the timing and duration of a warmed core temperature are factors that need to be considered when preparing for competitions.

2. At the start of a race, many swimmers have a lower-than-desired metabolic state. With marshalling of races, slow parades to the starting blocks, the tedium of introductions, and the sitting around involved in many of the stages of pre-race activities, the body's metabolism tends to be lowered. When a race starts, high metabolism demands of high-intensity performance are suddenly thrust on the swimmer. It takes considerable time for a lower-metabolizing swimmer to adapt to the new demands of a race. Activities are needed to decrease the difference between the metabolic level immediately before a start of a race and in the ensuing early stages of the race. The longer the adaptation period in a race, the less efficient will be the physiological function and greater the energy cost of the activity.
3. Stretching is the third physiological change to be considered in warming-up for swimming competitions. A side-effect of increasing the core temperature of an athlete is that flexibility is increased as the temperature rises. In reality, a small amount of mild stretching performed by a swimmer alone (dynamic stretching) is all that is needed to facilitate proper swimming movements in races.

Rushall (2009) critically analyzed flexibility practices and research. Much of the research that locates potential problems with common stretching practices apparently is ignored by many practitioners (e.g., athletic trainers, physiotherapists, etc.). Some of the concerns with commonly observed flexibility exercises at swim meets are listed below. They serve to warn coaches of what not to do to prepare swimmers to race in the best manner possible.

- Shoulders that are too flexible eventually lead to injury. There is no need to have extreme movement ranges in joints when those ranges are never used in the sport. Once excessive shoulder irritations have occurred, auxiliary training experiences (e.g., hand paddles, weight training, kicking with a board) also exacerbate the problems (Pollard, 2001).
- Joints that are too flexible lead to less efficient movements. Any increased habitual range of movement requires the muscles about the joints to function in a different range of movement than in normal structures. Usually, the muscle actions are weakened.
- Any stretching exercise involving another person is dangerous. When the "stretcher" is too active, injuries are very likely to result. When a partner applies excessive force to one or more joints to produce a movement range that could never be achieved through self-controlled actions it is termed "abusive stretching" because it does pre-dispose athletes to injuries by interfering with the tissues that support joint integrity

- (Yang, Im, & Wang, 2005). There is only one form of partner-stretching that is helpful, Proprioceptive Neuromuscular Facilitation (PNF; Holt, 1973; Holt, Pelham, & Holt, 2008). PNF requires disciplined participation on behalf of both persons in the exercise. Unfortunately, this valuable auxiliary training activity has been abused by many who do not strictly follow its procedures.
- There is considerable evidence about the negative effects of incorrect stretching on strength. Kokkonen, Nelson and Arnall (2001) found that extensive partner-assisted stretching (holding for 30 seconds which is considered to be abusive) caused a significant decrease in the number of repetitions in a hamstring strength endurance test. It was recommended that heavy static stretching³ of a muscle group intended for activity should be avoided before performances requiring a maximal strength endurance effort. In a later study, Nelson, Kokkonen, and Arnall (2005) found that static-stretching reduced muscle strength endurance. Force loss after prolonged static and passive stretching was shown (Behm, Button, & Butt, 2001). It was suggested that too much stretching decreases the capability for force production. Another study (Power et al., 2004) showed similar results and a negative association between increase in range of movement and maximal force and muscle inactivation. A thorough bout of ballistic stretching reduced the strength of the muscles stretched (Nelson & Kokkonen, 2001). Fry et al. (2003) reported that static stretching in close proximity to maximum power and strength activities has a detrimental effect on performance.
 - The current literature supports the contention that extensive stretching and in particular long static holding, reduces the strength generating capabilities of the muscles stretched. Explosive activity is also compromised. The elasticity of muscles and connective tissues are deadened and cause a loss in the development of power (Sayers et al., 2007). Since sprint-swimming is explosive, the performance of considerable formal stretching as a preparatory activity for racing should be re-considered. A conservative interpretation of the evidence suggests that excessive stretching programs should not be entertained before competing and their value for training should also be reconsidered (Rushall, 2009).

Raising the Core Temperature of the Swimmer

Raising a swimmer's core temperature is the first task of warming-up. It should be achieved before performing any activities such as stretching or dynamic exercise to lessen the likelihood of injury. Core temperature can be raised passively or actively.

Passive Warm-up

Any activity that raises the body's temperature without exertion such as hot showers, wearing multiple layers of clothing that prevent body heat escaping, heated clothes (e.g., battery heated body suits), and sitting in a warm part of the competition environment are some situations that passively warm the swimmer. Passive warm-ups usually take slightly longer to develop than active warm-ups. When activities are not possible, passive warm-up activities should be substituted. The most common time for this to occur is the time between completion of the active

³ Current static stretching appears to refer to and involve extended hold positions in aberrations of *PNF* and *SAS* stretching. In *SAS*, 10 seconds was advised originally but has risen to as much as 30 seconds in most of the recent investigations. In *PNF* work, the isometric contraction of ~6 seconds has also been extended to as much as 30 seconds. It is possible that 30 seconds is too long and could be the cause of detrimental effects on activity performance. The lower boundary of abusive stretching could be holds that are too extensive.

part of the warm-up and the approach to the starting blocks for a race. However, passive activities can be used to sustain a state of preparedness when there is limited time between races and when activities are largely prevented.

Passive warm-up activities are valuable for maintaining a warmed condition. After a full warm-up, the clothes worn by a swimmer can retain the heat generated by the warm body and prevent it from dissipating to the cooler ambient environment. Maintenance of a warmed body is dependent on not starting the actual warm-up too early. If the time from the start of the warm-up to the event start is excessive, then it is possible that some form of heat stress might occur, the commonest symptom being that the athlete starts to feel fatigued/tired even before the actual event. The onset of undesirable effects can be stalled somewhat if fluid intake is followed on a regular basis. The most obvious effect of extra fluid intake is that the swimmer will likely need to urinate close to the start of the event. A visit to the toilet is a late activity that is essential to create the most desirable condition before a race begins. As a general rule-of-thumb, the length of the final event preparation (warm-up or "race build-up routine" (Rushall, 1995)) rarely should be more than 30 minutes. A concerted focused deliberately-planned event warm-up should result in performance enhancement.

During warm-up maintenance, it is often a relief to remove the insulating clothing so that the skin surface of the swimmer cools. A brief exposure (e.g., 3-5 minutes) will not affect the deep muscle temperatures. If a swimmer is heard complaining about being too warm, a short skin-cooling event should be encouraged. Ideally, swimmers should know of the need to stay warm but also how to relieve excessive warmth without needing the coach's directions. That should be an integral part of a warm-up routine.

If a coach believes that an in-water warm-up is essential, then passive warm-ups are a good substitute for within-meet warm-ups and when water activity is not possible. The most positive attributes of a passive warm-up are that it can be under a swimmer's full control and has a low risk of injury.

Active Warm-up

In-pool activities. A very common sight at meets before competition sessions begin, is to see pool(s) crowded with swimmers doing their "warm-up" activities. One has to question the value of "herd swimming" of this type. Lanes are usually assigned to allow particular forms of swimming.

Swimmers are led to believe that pre-meet swims are important and participation usually is mandatory. A few of the factors that do not prepare a swimmer to compete well are listed below.

- Swimming circles with perhaps 10+ swimmers in a 25 m/y lane has no value. Any swimmer has to perform at the pace dictated by the group. As well, passing swimmers with whom an individual is not familiar poses an injury threat. Banging a hand on a lane rope, locking or clashing arms with a passing swimmer, and being kicked by the swimmer in front are examples of possible injurious events. If swimmers at training are limited to a particular number per lane, then the experience of greatly increasing swimmer density presents a higher threat than normal.
- The pace of swimming in warm-ups is not that which is ideal for individuals. The requirement to attend to external events to determine the pace of swimming makes the swimmer give up internal psychological control and proceed under external influences which is not a mental activity or state that should occur in a race. At competitions,

swimmers need to be in full control of their actions in all spheres so that in a race they swim their race rather than being influenced by events over which they have no control.

- In lanes assigned to diving, the experience of a hurried and possibly a panicked dive and swimming fast is hardly a preparation for racing. The turmoil that surrounds swimming in the dive-lane is counter-productive for any positive transfer to a focused controlled approach to later competitive events.

The experience of swimming in "warm-ups" before a meet serves no purpose that will enhance racing. The fostering of beliefs in swimmers that participation in this ritual is important only creates situations that will not be valuable for swimmers' conduct in the rest of the meet. On a day of competition, swimmers need to begin the day from the very waking moment ready to follow mental and physical activities that will enhance their likelihood of participating well and in a manner that is both pleasing and satisfying to all swimmers. It is opined that it is better to not participate in pre-meet warm-ups but to concentrate on maintaining focus, assertive control, and individualized activity schedules that lead to beneficial "race build-up routines" (Rushall, 1979, 1995). If pre-meet warm-ups are avoided, then many swimmers will be able to arrive later at the pool and continue with self-controlled behaviors.⁴

The possibility of actually "warming-up" in a pool is almost nil. Water is an excellent cooling medium. Matsunami and Taimura (2002) found that even when swimming in warm water body surface temperature was reduced by 3°C and only climbed slightly after 2,000 m of swimming. One should not expect medium to low effort level swimming to facilitate desirable improvements in core/deep muscle temperatures.

Late-preparation in-pool activities. Once the core temperature of a swimmer has been appropriately raised and there is time to perform unimpeded swimming that finishes no later than ten minutes before a race commences, it is possible to do some beneficial swimming. Such swimming should be simulations of race-pace for the upcoming event, preferably in a USRPT format. No exhaustion should be experienced (Pringle et al., 2009). The performance standard and mental content of such swims should be replications of what will occur in the ensuing race. Performing race-pace swimming so close to an event promotes "reminiscence", the state of the athlete being better prepared to repeat that quality of performance in the competing event. As well, any slow swimming at this time is unwarranted because it is counter-productive to the specific psychological effects that are only possible through race-pace work. Entering the water and immediately swimming at race-pace simulates what will occur in a race when an extensive period of out-of-water activity occurs and the first swimming has to be race-specific.

If the time of performing late swimming in the preparation routine is too far away (more than 15 minutes) from the ensuing race, the benefits of the activity are likely to be much diminished and no more effective than performance-enhancement imagery (Rushall, 1991). However, a difficulty with including late swimming in a race build-up routine is that it might only be possible to engage in it at a very few meets. That leads to the potential of a swimmer developing two forms of the race build-up routine, one being considered better (the race simulations in the

⁴ It is difficult to avoid the discussion of psychological factors when contemplating competitive situations. Competitions are where swimmers should be prepared to perform their very best and to relate their race performances to the training that preceded the meet. Nothing of a physiological nature can be improved on a day of competitions. Physiological factors, the main focus of this discussion, can only be manipulated so that the potential to race well can occur. Activities and events that have the potential to interfere with beneficial preparations and conduct at a meet should be avoided.

pool) than the other. It is more important to have swimmers believe they will race well because of the way they are preparing than to have them occasionally do some race-specific pool work.

Non-pool activities. The task of a warm-up is to raise the core (deep-muscle) temperature of the body. Physical activity of a continuous nature can achieve that elevation. The temperature increase response is accelerated if a swimmer's clothing prevents heat loss through convection with ambient air. Because pool swimming does not increase deep-muscle temperatures in warm-up conditions, some land activity (e.g., jogging, a calisthenics routine, brisk walking, stationary bicycle riding, rowing ergometer work, etc.) should be a standard part of a swimmer's warm-up routine. To achieve the basic physiological need of deep-temperature rise, the activity does not need to be swimming-specific and in most cases cannot be achieved by pool swimming in traditional swimming activities at meets.

To ensure that a swimmer has complete self-control of the race build-up routine phase of race preparation, only non-pool activities should be planned. The facilitation of race-skill levels is achieved by using the mental skills of performance-enhancement imagery (Rushall, 1991, 1995, 2003). Usually at age-group and sectional meets, in-pool activities cannot be performed in the 30-minute period before the start of a race. At higher level meets some in-pool activities might be possible.

Race Build-up Routine

The purpose of a race build-up routine is to elevate a swimmer's metabolism (a part of the state of "race readiness") to as close as possible to that which will be required at the commencement of a race. The structure of the race build-up routine is based on a number of organizational, physical activity, and psychological factors (Rushall, 2003). After sufficient practice and use at swim meets, it is unlikely that the routine would take longer than 30 minutes. If pool-swimming is possible and planned, it should be completed before the final 10 minutes of this routine. Every activity should be planned in detail. The purpose behind every activity should be defined.

- i. The task of preparing should be made as simple as possible by minimizing distractions (irrelevant stimuli) and maximizing the familiarity of the intended race performance (relevant stimuli). Elevated core/deep-muscle temperatures should be maintained or regained.
- ii. The simplicity of the build-up task should allow a swimmer to achieve a very high level of readiness for a race. That would be facilitated by constant activity which might include pool-swimming in ideal circumstances.
- iii. Deliberate control should be maintained over emotional states that are developed. The frequent swimmer-determined use of performance-enhancement imagery will sustain control and orient a swimmer's thoughts and actions towards the upcoming race.
- iv. Thoughts should be limited to self-control, positive orientations, the tasks of the build-up routine, and the intended race-strategy. This relies upon the swimmer being isolated from other swimmers and distractions.
- v. Thoughts should be narrowed as much as possible to produce the simplest cognitive appraisals of the intended race as the build-up routine progresses.
- vi. Emotional control and intensity should peak in the seconds before the race start.
- vii. The highest level of physical arousal (developed through physical and emotional activities) should be timed with the narrowest focus of attention just as the race is initiated.

- viii. The routine should be completed by a "pump-up" stage that accelerates readiness to its peaked state. The physiological arousal level should be as close as possible to the initial metabolic requirements of the race.

Throughout the race build-up routine, the level of physiological arousal (metabolism) should gradually rise. The timing of peak race-specific preparedness is usually left to the last part of the routine. To finish a good preparation, the last few minutes should involve both emotional and physical pump-up activities.

Emotional pump-up. This requires the swimmer to determine one or some emotions that will arouse them to become very assertive, determined, and probably aggressive. A repertoire of thoughts that will produce an increased emotional state (i.e., an increased level of metabolism) should be determined by and appropriate for the swimmer. Physiological arousal is fostered by this activity.

Physical pump-up. Physical activities have to be performed in concert with the emotional pump-up. The vigor, intensity, and constancy of the activities have to match the elevation in emotionality. If arm-swinging was such an activity, the speed of the rotations would be much higher 20 seconds before the start of a race than two minutes before. Similarly, if jumping was an activity the frequency and the height of the jumps would be noticeably greater just before the race start than several minutes before. This physical activity serves to control the emotional pump-up so that it does not become excessive. For example, if a swimmer senses being too nervous, the amount and intensity of physical activities should be raised to bring race-readiness back under control.

Figure 1 displays a sample pre-race strategy for an on-land race build-up routine. The use of performance-enhancement imagery⁵ with its important physical movement component is threaded almost throughout the whole routine. Two necessary psychological features are added to the primary/preferred behaviors that serve to elevate the effects of a strategy of this form.

Extensive research has investigated the effects of setting goals on performance. Elite athletes, and by implication all serious athletes, wish to be involved in the determination of performance goals in consultations with the coach (Rushall & Garvie, 1978; Rushall, Jamieson, & Talbot, 1977). Each primary behavior in a strategy should have a swimmer-defined goal/purpose. The strategy planning worksheet (Figure 1) has a column in which the goals of all specific behaviors are defined.

A coping alternative for each preferred behavior in a strategy is better than a strategy in which there are no coping alternatives. They produce improved performance output and tolerance to stress (Andrew, 1968; Meichenbaum & Turk, 1975). Predicting and preparing for problems will produce better tolerance and coping responses in performance (Aderman, Bryant, & Domelsmith, 1978). Better competitive environment behaviors and situational coping is achieved by swimmers defining another behavior other than the primary behavior for achieving the same goal. The strategy planning worksheet has a column in which alternative coping behaviors are to be defined.

One important teaching point that should be stressed particularly with young swimmers is to never copy any activity or exercise performed by other swimmers at meets. The downside of

⁵ The amount of imagery is particularly individual. It is best to let the swimmer determine when to do the activity and how much should be done. The higher the performance level of the swimmer, the greater is the amount of imagery performed (Partington & Orlick, 1986).

The elevation of the core/deep muscle temperature does not require in-pool activities. The cooling effect of water makes it most difficult to raise the core temperature. Non-pool activities with some insulation rendered by clothing are much more effective for achieving warming effects in a relatively short time. The maintenance of elevated temperatures is best achieved on land.

Any swimming that is not at race-pace will not transfer beneficial effects to subsequent race performances. The execution of performance-enhancement imagery on land does affect subsequent race performances. Irrelevant pool swimming is not as effective as relevant swimming imagery for influencing race performances.

The atmosphere of pool warm-ups, with the high degree of external control of swimming paces, the internal need to avoid injury in crowded lanes, and hurried starts and frenetic swimming, are features that detract from the development of beneficial mind-sets and relevant physical activities. On the other hand, non-pool warm-ups can be conveniently performed under a swimmer's self-control in a confident manner. In correctly prepared warm-up strategies, not only are preferred/primary behaviors planned but in case any of those behaviors do not achieve the goal of their execution, a secondary coping behavior to achieve the same goal is planned.

There is little of value for warm-up purposes to be achieved by pool swimming before the commencement of a meet. It only has the potential for negative effects. If swimmers have been made to believe that a pre-meet warm-up must be performed in order to swim well for the rest of the meet then any effects that occur will be a placebo. Adopting such unfounded beliefs has a large negative potential. If a swimmer is unable to participate in the pre-meet activity, then a nocebo effect occurs. Swimmers will believe they cannot swim well because they did not do the pre-meet warm-up. This is a consequence of all unfounded "causal" beliefs associated with swimming. If the activity cannot occur, then the beliefs are negated and usually cause a loss in confidence, performance expectations, negative participation, etc. Establishing a swimmer's reliance on any superstition or unfounded belief is dangerous and does much to influence a swimmer's appraisal of participation in the sport. That being said, there is one valuable factor derived from pre-meet swimming in the competition pool. Familiarization with the swimming environment, such as what the walls feel like for turns, reading the markings on the pool bottom and walls, noting the 15 m lane marker, etc., can be used advantageously. The familiarization feature that is most common is adapting to the competition pool depth. When the training pool is perhaps 3.5 feet deep at one end and the competition pool is three meters deep at both ends, reading the "T" on the black line to time a turn is a very different experience⁶. In subsequent performance-enhancement imagery, the discovered eccentricities of the competition pool can be included in the sight-aspects of the imagery. If warm-ups are not in the competition pool, this potential positive influence will not occur.

The preponderance of research on warm-ups in swimming involves in-pool activities very close to the criterion performance. In the few studies that have evaluated non-pool activities there has been no difference in effects. Thus, land-based warm-ups are just as viable for swimmer preparations as pool warm-ups. They are decidedly more convenient and can be timed to suit the needs of the swimmer for an individual approach to race preparation.

Land-based warm-ups provide every physiological and psychological benefit that might be imagined as occurring in pool activities. The psychological effects of a self-controlled planned

⁶ If swimmers are taught to use the 5-m lane line change at each end of the pool to gauge their turning actions, adjusting to the depth-optics is not that important.

set of activities that have been practiced and refined are much greater than what might be achieved in a pool. Land-based warm-ups achieve all the physiological factors deemed to be essential for race preparations.

Land-based warm-ups have another decided advantage for swimming as a sport. It is a common practice to do in-pool warm-up swims at practices. In some situations, those activities can consume as much as 25% of a two-hour practice. For the improvement of race-pace performances, long warm-ups serve no valuable purpose. On the other hand at practice, if swimmers warm-up before pool swimming is possible, then the full two-hour practice will be made available for potentially beneficial training. Land-based warm-ups release as much as 25% of pool time for extra training. That is a simple way of increasing the amount of training performed by swimmers without requiring them to participate in longer or more frequent training sessions.

Since races occur and are preceded by land-based activities, having a similar requirement at practices is a training experience that is relevant for race preparations. In the USRPT realm, having swimmers participate in a race-pace set immediately upon the commencement of practice is a race-specific set of conditions that can be refined with repetitions. When swimmers understand and see the effects of land-based pre-practice activities of their own design, confidence and fast-swimming readiness are bolstered appreciably. That is highly desirable for competing.

A further justification for land-based warm-ups is that pool warm-ups cannot be completed in the time frame where they might benefit a race performance. It is not known if a very well planned land-based warm-up is more effective than any pool warm-up. Logic and reasoning suggests that land-based warm-ups are best. That is a reasonable hypothesis.

Attributing placebo effects to ineffective pool warm-ups performed well outside the period when they might be effective is a dangerous practice. Placebo effects can be reversed by the "believed activity" being prevented or disrupted. Land-based warm-ups are flexible in time and environmental needs and stimulate swimmers to become responsible for their pre-race and race performances at any meet. Self-controlled warm-ups are one avenue for having swimmers develop focus and assertiveness in the lead-up to races. Land-based warm-ups are preferable to any pool-based activities.

Land-Based Activities

Land-based warm-ups require continuous/frequent physical activity of low demand, clothing that retains heat across the swimmer (head to toe), and swimmer determined mental activity that is race-specific. One of the most common physical activities will be light dynamic stretching. An already warmed body will facilitate greater movement ranges than when normally "cool". The aim of free-stretching at this time is to allow swimmers to feel good without exertion. Unfortunately, aggressive and ineffective/debilitating forms of stretching are popular and need to be avoided (Rushall, 2009). The following are recommended principles for use when considering doing sane stretching for swimming training and competitions (Rushall, 2009).

- Do not perform any stretching activities that stress the joint tissues or structures.
- Perform only swimmer directed activities that contribute to the swimmer feeling good.
- Do no exercises that bounce or force a joint beyond a natural range of movement (the voluntary stretching limit).
- Only use a partner for stretching activities if the partner is knowledgeable about and adheres to the correct execution of PNF stretching.

- Slow stretching should follow a physical warm-up but precede any skill and intensity specific activities. [PNF stretching has been shown consistently to be the only protocol that produces beneficial effects. Coaches should be wary of individuals promoting any other form of stretching.]
- No stretched position should be held other than in the PNF procedure.
- Once specific race preparations begin after warm-up, no further formal and deliberate stretching should be performed. The stretching of soft tissues should be achieved through swimmer-directed activities that are performed to meet the particular needs of the moment.
- If any stretching produces pain or *DOMS* that keeps returning after each stretching session, cease the stretching activities.

Many races are won or lost because of psychological, not physiological factors at the competition venue. Therefore, manipulating activities to best prepare the psychological states of swimmers before races is the primary role of swimmers' training and relating practice activities to meet activities. If land-based warm-ups are to be used at competitions then they also should be the standard introductory activity for practice sessions. That is important for USRPT programs. Immediately following individualized practice-session warm-ups swimmers should be expected to learn how to immediately perform with race-pace quality and efficiency upon entering the water for the first time. That replicates most competitive situations. It should better prepare for the demands of swim meets.

One of the foremost and original pioneers in designing warm-ups for swimming competitions was the Sydney University physiologist and Australian swimming coach, Forbes Carlile. In his landmark 1963 book, Carlile described a land-based warm-up which is as relevant today as it was then.

If the conditions are very cold in an outdoor pool, it is sometimes best not to go into the water before the race but to carry out all the other warming-up activities.

It is an advantage for the body temperature to be raised before racing. For this a hot shower or hot bath should be used either at home before going to the pool or at the pool, or in both places. The water should be just about as hot as the swimmer can bear, then thorough warming up (enough to cause sweating) needs about five minutes in the bath or seven minutes under the shower. The hot water treatment should be followed by a short cold shower to close the skin blood vessels. The hot shower at the pool should be taken after the pre-race swim. In 1947 we carried out a series of careful scientific experiments (over 400 individual swims were involved) which proved that this 'passive' warming-up was helpful.

While waiting for the race, be sure to put on warm clothes and cover the feet. The swimmer should alternate between lying down (have a rug and if possible a mattress) and walking around and exercising. Our experiments showed that even in a warm atmosphere, if a swimmer is immobile for a while, isolated muscles can become cold, actually falling to 2 or 3 centigrade degrees below blood temperature. This can greatly lower the work capacity of the muscle. Exercising the muscles and running from time to time will keep the muscles warm. In Australia, I insist on my pupils running as part of their warm-up, either up and down the corridors of the pool or where possible outside on the grass. Do not sit still for long. Keep moving! Keep warm! (Carlile 1963; pp. 37-38).

Genov (1970) stipulated 12 influential factors for the development on an appropriate psychological-physical readiness state for a competition. These factors should govern any race build-up routine.

- i. The structure and content of performance preparation is dependent upon the type of activity/event. Even within the same sport but for differing events, the preparations will be different.
- ii. Performance preparation is more effective the higher the level of performance classification of the athlete. Pre-competition preparations become more and more important as the skill-level of the swimmer increases.
- iii. The surroundings and conditions of the competition affect performance readiness. Unfamiliar situations and events reduce the degree of readiness unless adequate coping strategies exist and the length of the warm-up routine is extended.
- iv. The personal and social importance of attaining the performance goals affects the amount or level of readiness. The incentives (goals) for performance affect the measure of preparation that is required.
- v. The swimmer's self-assessment of the preparation and determination to achieve goals affects the readiness to perform. The more important the event is for the swimmer the longer should be the warm-up. Self-developed and self-controlled preparations maximize this feature.
- vi. The greater the degree of difficulty of the event, the higher the level of readiness that is required. The more serious the competition then the more intense should be the preparations and the higher the level of arousal should be at the race start.
- vii. The experience of the athlete in forming similar states of readiness affects the degree of effect of the preparation. Preparations are skills which need to be learned and practiced.
- viii. Reduced health states, fatigue, or injury require greater conscious efforts to prepare adequately for a race.
- ix. The emotional state prior to the commencement of preparations affects the application to and standard of readiness. It is necessary to eradicate unfavorable circumstances and to develop a good positive atmosphere and attitude in the swimmer before pre-competition activities.
- x. Competition readiness is hindered if insufficient time is available. The more difficult the race, the greater is the time required to achieve peak preparedness.
- xi. Race preparations are peculiar to the swimmer. Activities must be personalized for each individual.
- xii. The athlete's skill ability in performance-enhancement imagery and the physical content of the preparations affects the level of readiness that is achieved. The content of preparations needs to be experimented with, evaluated, and altered where necessary.

Although not in a swimming environment, Ingham et al. (2009) showed that a longer duration warm-up with intensity-specific activities promoted readiness for performance better than a less demanding and less specific set of activities. The length of involvement needs to be longer, the intensity of the preparatory activities should be higher, and the relevance of the mental activities (including self-talk) should be event-specific the higher the importance of the competition. The features of a correct race-preparation need to be practiced. Having the same warm-up routine for practice as is required for races would seem to be a logical fulfillment of that need. The variation of intensifying and extending the warm-up content for more important swimming competitions should be planned well in advance of important meets and practiced as part of the learning experiences associated with swimming training sessions.

Implications

Warm-ups for swimming meets and races need to be considered for particular races. The traditional swimming "warm-up" in a crowded pool before the meet session begins serves no constructive purpose. If swimmers have been taught to depend on the importance of the unproductive pre-meet warm-up, any effect will be of placebo in nature. That presents the danger of a disruption to the arbitrary activity reversing the placebo effect (a "nocebo" effect) which is unfortunate. Effective warm-ups must occur close to races, be of activities that are relevant for performance enhancement, and be totally under the control of the athlete that has devised the preparatory strategy (the "race build-up routine"). This writer has often opined that the preparation for a race governs at least 50% of the ensuing performance. It has great potential for performance enhancement.

Race build-up routines can be performed completely on land and do not require swimming. If swimming is involved it should be race-specific in pace and stroke and of short duration so no appreciable energy loss is perceived by the swimmer. Land-based warm-ups can be the warm-ups at practices. That decision releases more pool time for effective training rather than performing questionable water activities.

The most practical model of a warm-up is to use the same warm-up at meets as is done at practices. If a 30-minute race-build-up routine⁷ is developed, it should be practiced and learned fully. Swimmers should be expected to arrive at training in sufficient time to do their land-based warm-up before pool swimming commences. The prepared routine can be used in a number of ways. If a swimmer arrives late for a training session (e.g., 10 minutes before swimming begins) then the build-up routine should be entered at the 10-minutes-to-go point. Having a set build-up routine allows a swimmer to enter at the appropriate time point so that the first USRPT task will be attempted in a reasonable state. The same application works at dual high school and college meets. It is commonly observed that after a race in the short time (e.g., 15 minutes) before the next swim that swimmers bide their time on deck or if facilities allow it do slow "recovery swimming" in another part of the pool. Those activities do not prepare swimmers for the next race. What should happen is that upon completion of one race swimmers should enter the build-up routine at the appropriate time point to prepare for the next race. Two good effects occur if that is done. First, the likely higher intensity activities of the race build-up routine will promote faster recovery from the previous race than would "easy recovery swimming". Second, the swimmer focuses on swimming well in the next race rather than recovering from the previous race. That approach to between-races activities will be very different to traditional swimming lore. If a race build-up routine becomes part of all facets of an individual's swimming, then swimmer conduct before pool swimming at training and meets will be predictable and part of the swimmer's psyche for performing successfully. That understanding is radical for traditional coaches but should be part of the conduct of USRPT programs.

Once race build-up routines are formed, when they are used in competitions is likely to require some modifications in both time and intensity of preparation (as described by Genov, 1970). Modified land-based routines can be practiced several times at training before a meet so that the swimmer will be confident in the preparations that occur on most important occasions.

Too much emphasis on the wrong activities has become a hallmark of traditional swimming warm-ups. It is time to readjust the content and purpose of this important activity to pre-dispose

⁷ Young swimmers will likely prepare routines that are much shorter in duration. The 30-minute model is close to that which needs to be executed by senior/national-level athletes.

swimmers to better performance outcomes. In keeping with the USRPT philosophy of only following activities that are based on science, land-based self-developed race build-up routines will satisfy that restriction.

This discussion was limited to considering the three physiological features of a race warm-up. The involvement of psychological activities, strategies, and skills can be considered to be more important. Those factors have been covered in depth in three publications by this writer (Rushall, 1979, 1995, 2003). The incorporation of psychological and physiological states and activities as warm-ups should lead swimmers to commence races in the best state possible.

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