

Contemporary practices of high-performance swimming coaches on pacing skill development and competition preparation

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Abstract

Pacing is arguably more crucial for optimal performance in swimming than in land-based sports, however little is known about the process of developing pacing skills in swimmers. The aim of this study was to examine the current practices of high-performance swimming coaches in relation to pacing entrainment and competition preparation. Twenty-one swimming coaches who were currently coaching or had coached swimmers at national open, international age or international open level, participated in a semi-structured interview. Interview transcripts were examined using hierarchical content (qualitative) analysis to identify general dimensions, higher-order themes and sub-themes. Data were categorised into two main areas: training and competition. The general dimensions of monitoring, pacing aids, periodisation and training for multiple events emerged within training; whereas optimal strategy, racing, warm up swims and multiple main events emerged within competition. Coaches identified the importance of a highly individualised approach based on swimmer needs and characteristics. However, the difficulty in achieving this goal when working with large groups of swimmers was identified as a challenge. Although swimming is a time-based sport, efficient technique and pacing were considered vital to success. Despite this, it appears that key variables including stroke rate, stroke count, split times and rating of perceived exertion were not monitored by a number of coaches. These parameters are likely important tools to maximise pacing skill development, especially in young swimmers. However, given the current lack of information on how athletes learn and develop pacing skills, coaches would benefit from evidence-based guidelines in this area.

Keywords

pacing, periodisation, swimming performance, training

Introduction

Pacing is defined as the distribution of energy expenditure throughout an exercise task^{1,2} and poor pacing can negatively impact performance in many sports. Given the highly resistive properties of water and the low mechanical efficiency of swimming,^{2,3} pacing is arguably more important in swimming than in land-based sports. Velocity in swimming is the product of stroke rate (SR), the number of stroke cycles per minute, and stroke length, the distance travelled with each stroke cycle, where an increase in one typically leads to a decrease in the other.⁴ Pacing profiles adopted by elite swimmers in competition have been well characterised by plotting speed, lap time or percentage of overall race time for each lap within a race.²

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These graphs display the shape of the pacing profile for a given event and the resulting profiles are typically highly reproducible within and between competitions.^{5,6} Despite these descriptive analyses of pacing profiles in swimming competitions, it is unclear whether the profiles displayed are optimal for performance.² While many coaches and swimmers train to execute a specific strategy in relation to pacing for a given event, the observed pacing profiles may not always be reflective of successful execution of a pre-planned pacing strategy. Although swimmers' race in their own lanes and therefore do not have to fight for positions, pacing profiles may be impacted by psychological factors, actions of opponents and race tactics.²

The mechanisms of pace regulation are complex, however a combination of sensory feedback, anticipation, knowledge of the end point, and prior experience are likely important.⁷ Therefore, practice over several years is usually required to develop and perfect an individual swimmer's overall performance template.⁸ While youth athletes possess a level of pacing ability from a young age, it appears that self-regulation and cognitive and intellectual development influence pacing skills which continue to develop through adolescence.⁹⁻¹¹ Coaches play a pivotal role in the development of their athletes, and it is important they have the appropriate knowledge, attributes and skills to coach athletes effectively. Coaches typically learn from a variety of sources including formal coaching certificates and education, although the time invested in these programs is often small.¹² Anecdotal evidence indicates that current coach education programs in swimming provide limited information on the development of pacing behaviour. Other forms of learning such as nonformal coaching conferences and workshops, and informal peer-to-peer interactions with other coaches or self-directed learning, may be beneficial to coach development in this area.

To improve pacing skills in swimming and identify possible areas for coach and swimmer development, it is important to understand the current practices and philosophies of high-performance swimming coaches. These coaches have developed highly specialised knowledge gained from several years of experience.¹³ Exploring these sources of knowledge provides the opportunity to improve our understanding of the process of training and competition preparation in swimmers. The aim of the training process is to prepare athletes for competition over a period of several weeks, months and years.¹⁴ Pacing skills are essential in both training and competition, and therefore it is important to explore how coaches' approach both aspects of performance to gain a holistic view of current practices. Lower level coaches would likely benefit from this sharing of coaching knowledge and allow them to learn

more about the training methods utilised by elite coaches, which may then positively impact their own coaching practices in the future. These insights would also help sport science practitioners in the provision of evidence-based, practical recommendations on specific strategies to develop pacing skills in swimmers.

The aim of this study was to examine the current practices and philosophies of high-performance swimming coaches on the programming and periodisation of training to teach and develop pacing skills, as well as competition preparation and practice.

Methods

Participants

Twenty-one swimming coaches volunteered to participate in this study (18 males and 3 females). All coaches were previously swimmers themselves and were currently coaching or had coached swimmers at national open, international age or international open level. Thirteen of these coaches have coached an Olympic or World Championship medallist. All held bronze, silver, gold or platinum Swimming Australia coach accreditation and had 21 ± 11 years experience. Signed informed consent was obtained prior to commencing interviews and the study was approved by the University of Canberra Human Research Ethics Committee (project number: 17-142).

Research design

A semi-structured one-on-one interview was conducted with each coach using thirteen open-ended questions as a guide (Table 1). The guide was developed by the research team, which was comprised of sport scientists and university researchers with extensive swimming-specific knowledge. The semi-structured nature of the interviews allowed detailed responses and provided the lead researcher with the opportunity to ask additional follow-up questions when required.¹⁵ The questions were piloted with a former high-performance coach of an Olympic Medallist and their feedback was used to evaluate and improve the clarity of the questions. The aim of these interviews was to gain insight into the design, programming and monitoring of training, the tools and approaches used to select and entrain pacing skills and race specific pacing strategies. Furthermore, the coaches were asked about competition preparation which may have direct links to pacing, including the use of minor competitions throughout the season to practice pacing strategies for their main event, the use of warm up swims to practice parts of the pacing strategy, and how the coaches prepare their swimmers for longer meets where each event requires a different

Table 1. List of interview questions on coaching practices.

1	How many race pace sessions do you program into a typical training week? Does this change throughout the season?
2	How do these sets progress throughout the season leading up to the major competition?
3	What do you monitor during these sessions?
4	When do you start to bring in broken swims, time trials and race simulations?
5	How do you determine each swimmers' optimal pacing strategy for their main event(s)?
6	Do you currently use any pacing aids in training? If yes, please specify.
7	How many preparatory competitions & how often do your swimmers race in their main event(s) prior to the major competition of the season?
8	How many events will they typically swim at these preparatory competitions?
9	At the major competition, do your swimmers race any warm up events prior to their first main event to get into race mode or to practice pacing? If yes, do you think this helps maximise performance in their main event(s)?
10	What do you recommend to your swimmers at international meets such as World Championships where it is not possible to enter more events?
11	How do you plan and program race pace work in training for a swimmer who has more than one main event with distinct pacing strategies?
12	If a swimmer has one of their main events on the first day of competition, and the other on the last day, how do you alter the planning of the taper and how would you plan the days in between the two races?
13	Do you have any further comments regarding pacing or competition preparation?

pacing strategy. All interviews were conducted by the lead researcher who has ~4 years' experience as a sport scientist in high-performance swimming. Interviews lasted between 5 and 48 min (mean 20 min) where one interview was conducted via the telephone and the rest were face-to-face, typically taking place at the swimming pool where the coach worked. Interviews were recorded and transcribed verbatim by the lead researcher. An identifying code was assigned to each coach and data were labelled accordingly.

Data analysis

Hierarchical content analysis was used to establish general dimensions, higher-order themes and sub-themes.¹⁶ The lead researcher became familiar with the data by listening to and reading each transcript at least twice. Segments of relevant and meaningful data were identified and clustered into themes using NVivo 12 software. Data was thoroughly cross-checked to ensure all relevant information was identified. The interpretations of the lead researcher were discussed with two independent professionals with swimming-specific experience and knowledge. The different perspectives and critical feedback provided in this 'critical friends' process were used to enhance rigour of the analysis.¹⁷ This type of analysis was selected as member checking and inter-rater reliability assessments are ineffective methods to develop rigour in qualitative research.¹⁷ Qualitative research can positively impact sports performance by bridging the gap between research and practice,¹⁸ and similar methods have recently been utilised in the area of mental fatigue.¹⁹

Results

Following analysis of the interview transcripts, data were categorised into two areas: training and competition, where four general dimensions emerged in each area. For training the dimensions were: (a) monitoring, (b) pacing aids, (c) periodisation and (d) training for multiple events. For competition the dimensions were: (a) optimal strategy, (b) racing, (c) warm up swims and (d) multiple main events. Within each dimension at least two higher order themes emerged, of which some also contained multiple sub-themes. To provide context to the theme development, coach quotations associated with each sub-theme, higher order theme and general dimension are provided in Table 2 (training) and Table 3 (competition). Data saturation was assumed as multiple participants were asked the same questions and no new themes or coding emerged.²⁰

Training: monitoring

In the monitoring dimension, the higher order themes of variables and challenges were identified. Coaches listed the variables they typically monitor during race pace training sessions – the most common responses were overall times, split times, SR and stroke count (SC). Two of the coaches did not report monitoring SR and eight did not report monitoring SC. While all coaches spoke about monitoring overall times and/or swimming speed, only six reported taking split times. Other less common variables mentioned include heart rate, blood lactate concentration, rating of perceived exertion (RPE), recovery speed, turn times, kick count and balance, breathing patterns and body

Table 2. Themes and quotations from coach interviews relating to the training process.

General dimension	Higher order theme	Sub-theme	Quotation
Monitoring	Variables		'Kick count, stroke count, stroke rate, heart rate and time'
	Challenges		'Stroke rate is one of the things I kind of think when you've got 30 swimmers, I do what I can'
Pacing Aids	Aids used		'Tempo trainers and pacing lights for turns, but we haven't used them in 6 months'
		Usefulness	General
		Session type	'Normally race specific sessions and I wouldn't try it with all of them, just a few of them'
		Stroke specificity	'I don't think it works for all strokes though, I think it's really hard for fly, it's great for backstroke, really good, backstroke and breaststroke'
		Event specificity	'More with a distance athlete on the tempo trainer, because they're more a tempo kind of thing'
		Alternative methods	'We go what rate was that and they go 52, no it was actually 48. I find that more effective than a tempo trainer, so they have to take ownership of their rate'
Periodisation	Race pace sessions	Frequency	'Specific race pace would be two sessions per week'
		Coach philosophy	'I talk about rates and counts and then time will take care of itself as the season goes through. So obviously at the end of the season you need to be hitting the time, but I think it's irrelevant if you're over-rating or over-counting for that time'
		Progression	'What I'd like to see is the progression where they can first get to the time and then reduce the interval and maintain the time. So, you are trying to combine the right stroke length, stroke rate to get velocity, reduce the rest'
	Broken swims		'Broken swims come in four weeks out'
	Time trials		'Generally, out from a meet we'll do a time trial 21 days, 14 days and 7 days out. I might do time trials 4 weeks in a row or I might do a heat, semi and final swim, full race scenario'
Training for Multiple Events	Combined sessions		'It's generally always combined, a lot of it will be descending down'
	Separate sessions		'Focus on them at different times of the week. Normally I would go maybe 200, 400, 800, 1500 so longer distances throughout the week'
	Periodisation		'Early season separate it more, more blocked so the learning is blocked. Late season vary it up a bit and put both in the same session'

position. Five coaches spoke about the challenges of monitoring SR and/or SC with a large group of swimmers:

No stroke rates or counts, too many kids. Sometimes we ask them to count their strokes. (C12)

Training: pacing aids

Pacing aids used include pacing lights, a series of underwater lights placed on the bottom of the pool; Tempo Trainer™, a metronome placed under the cap;

TritonWear™, a wearable tracking device that sits under the cap; and AutoCoach™, a stopwatch and speaker system providing real-time feedback to swimmers. Only two coaches were currently using one of these aids. The importance of not becoming reliant on pacing aids and keeping things simple was highlighted:

Try to keep it as simple as possible without too many tools because I think the more tools you incorporate the more complicated it can get, the more time it takes to fiddle around and get things adjusted and I don't want to waste time. (C2)

Table 3. Themes and quotations from coach interviews relating to the competition environment.

General dimension	Higher order theme	Sub-theme	Quotation
Optimal Strategy	General philosophy		'My basic thing for the race execution I talk about that relaxed speed through the front part, consolidate and keeping pressure on the middle and coming home strong in that last 50, it's how we swim'
	Information used		'Look at what their best time is, and the way they swam it, because that's relevant to them, splits and rates, counts if they've got them. And then I want them to look at what the best in the world are doing'
Racing	Frequency Purpose		'Usually I'd like to race once every 3–4 weeks'
			'There's always a reason for racing, it's not just turning up and having a swim. It's all based around what you want to do at the major meet'
	Event selection	Periodisation	'Early season they will generally swim some other ones as well, some fun events, late season generally just swim them in their specific events'
		Stroke	'If it was a backstroker that I had then they are normally pretty good at freestyle, so we'd swim backstroke and freestyle'
Warm up swims	Rationale	Environmental	'Know what the environment is and they know what to expect'
		Psychological	'Gets them in the zone, gets them in the right frame of mind'
	Utilisation		'I like to, this year I'm not because the program is so short, but I like them to have a hit out'
	Alternatives	Options	'Get them to do say a broken, possibly even like a heat and semi-finals or a heat and final, so they've got time to recover'
		Timeline	'Probably do a hit out 2 days out, so some kind of part of their race where I'd be looking for some splitting strategy'
Multiple main events	Taper		'Taper towards the first main event and then just hold them through the rest of the meet until their next main event'
	Competition management		'I'd still do aerobic work, I'd still do speed work, I'd still do race pace work, but the amounts that you would actually do would vary depending on the individual'

I don't like relying on them all the time because you know it's more a case of using it to set the rhythm and then leaving it, we don't tend to use them extensively. (C5)

Several coaches mentioned they would only use pacing aids in specific sessions and for some strokes and events. Coaches believe that a metronome is most useful for backstroke and breaststroke, as well as distance freestylers. In relation to the AutoCoach™ system one coach said:

It is very effective when they swim particularly 200-400m repetitions, you can give them feedback for the first 50 or 100m and they start pacing much better. (C21)

Three coaches spoke about alternative methods they use to train pacing such as turning the pace clocks off and asking swimmers to guess their times and/or SRs with the aim of making them 'a smarter swimmer' (C16). There was uncertainty around the duration of pacing entrainment, 'how long does it take someone to learn to pace' (C15). The need to develop pacing ability from a younger age was identified as important:

I think maybe we should be doing that more with younger swimmers, thinking about it now, play games, turn the clocks off to see what time they think that is. Surely if we start doing stuff at a younger age they are going to be

better at it at an older age. Don't wait until we get to 14 or 15 when they are at a national level to start learning to pace. (C15)

It's a great laugh, we play the game what time did you do, I do that regularly, what time and I'll tell you what I think, what rating and I'll tell you what I think and we see who is closer. (C16)

Training: periodisation

The frequency of race pace-specific sessions was typically 2–3 per week, with some coaches reporting as little as 1 and as many as 6. Five coaches keep the number of specific race pace-specific sessions consistent throughout the season, whereas the others alter the number of sessions depending on the training phase:

We'll do two major race pace sessions and then when we're closer to competition I'll add in a third. (C9)

Number of sessions doesn't really change throughout the season but probably the content is something that's different. (C14)

In terms of coaching philosophy, the need to develop stroke efficiency early in the season with little focus on times until closer to competition was identified by most coaches. One coach spoke specifically about their general approach for 200-m race pace work:

When you're doing your pace work it's got to be a 7.5 out of 10 for 200 pace and always emphasising relaxed speed front end, keeping pressure on the middle and monster back 50. Using those little cues or key words with the kids when we're doing the broken stuff as well. (C13)

Common progressions of race pace-specific sets include gradually increasing the volume and intensity of the sets, reducing the amount of rest between repetitions and the number of repetitions to more closely replicate the race, adding constraints such as pre-fatigue and increasing the specificity in relation to the event demands:

What I'd like to see is the progression where they can first get the time and then reduce the interval and maintain the speed/time. So, you are trying to combine the right stroke length, stroke rate to get velocity, and reduce the rest. At one point increase the total volume of that component of race pace work and then reduce it going into the event. At which point, very close to the event, you

might go that same set in a swim suit but much shorter rest, trying to get everything ready. (C4)

Once they are in a fit enough state obviously to execute race pace, I'll ask for various paces and then either create a lactate loading or an aerobic/heart rate loading before asking for the paces so trying to create as many different types of stressors and still expect the paces. (C19)

Some coaches incorporate broken swims throughout the season as an extension of race pace work, while others introduce them 4–8 weeks prior to competition. Typically, a broken swim is where a race is broken down into smaller segments with short rest intervals e.g. a 200-m race is broken down into 4 × 50-m repeats with 10–20 sec rest. One coach spoke about using broken swims as a way of learning how to swim an event:

Broken 800 m and they are learning how to pace so 4 × 200 or 2 × 400 and they are learning how to swim it. (C21)

Similarly, some coaches use time trials throughout and others bring them in 2–8 weeks prior to competition. Generally, coaches prefer to use competitions rather than time trials in training, however if suitable competitions are not available a time trial would be used as an alternative. Simulation of morning heats and evening finals within the same day using time trials in training was common practice.

Training: training for multiple events

When swimmers are training for multiple events most coaches prefer to keep the sessions separate, for example a 200, 400 and 1500-m race pace-specific session on different days throughout the week. The main reason for preferring this approach was differences in SR, SC and 'feel-for-the-water' between events. Six coaches spoke about putting the faster paced sessions earlier in the week, when the swimmers are potentially less fatigued after a recovery day which typically occurs on a Sunday. Other coaches combine race pace-specific work for different events into the same session, for example starting with 400-m race pace then building into faster 200-m race pace efforts. Alternatively, one coach uses separate sessions early in the season and shifts to combined sessions later in the season. The focus can change throughout the season, where earlier in the season emphasis is on the longer distance events – closer to competition the emphasis shifts to shorter distance events:

I have blocks of preparation, more focusing on pacing for the 400 m during the general and specific endurance phase and then they start focusing more on 200 m pacing closer to competition. (C21)

Starting with the longer distance races at the start of the block and then coming down decreasing the pacing into faster, shorter distances as we get closer to racing. (C10)

Competition: optimal strategy

Many coaches have a general philosophy on how certain events should be swum, however they also highlighted the need for the race strategy to be tailored to each individual swimmer. Information used to develop individual race-specific pacing strategies include race data from previous swims, race data for the top ranked swimmers in the world and close competitors, strengths and weaknesses both physiologically and biomechanically, results from test sets and responses to training and racing:

We do efficiency tests and that's how we make up the basis of our pacing. Or you look at a broader scale what generally everyone is doing in the world and you can come up with kind of a model or system, but it has to be specific to your athlete. If you've got a kid who isn't anaerobic, there's no point trying to get them to swim with a 50 SR in the first 50 m of a 200m, it has to be specific to them. (C6)

Competition: racing

Generally, coaches want their swimmers to race every 3–6 weeks, however some only have 2–3 competitions prior to the major competition of the season, while others might prescribe an intense race block where they race weekly before starting a taper period. Racing frequency is also dependent on the swimmer and one coach said, 'he often prefers to have good solid training blocks without interruptions of races' (C5). Two coaches mentioned they would prefer more opportunities to race:

I would say if they are probably getting 3 or 4 good competitions in a season that's pretty decent, but I'd like it to be more. I would love it if it was about one a month, and then maybe 2 months out there might be 2–3 in that month maybe, then not heaps in the actual month of. (C17)

Planning to execute a specific part of the race, a form of conditioning, focusing on the process such as hitting the desired SR and SC and practising race day

protocols were listed as reasons for racing. Event selection at competitions varies depending on the time in the season, the main stroke of the swimmer and the competition duration and schedule:

We usually pick one event every preparation where they swim a lot of events so they become race resilient, but the other ones more specific. (C18)

Main events probably plus one that's a little less important to them but it depends on the athlete as well. I probably don't like any more than 4 swims a day so if it's heats and finals, 2 in the morning and 2 at night. (C3)

Competition: warm up swims

Rationale for the use of warm up swims include becoming familiar with the competition environment, the need to settle into the meet and to 'blow the cobwebs out' (C20). Some but not all coaches like using warm up swims for these reasons, however it is dependent on the needs of the individual athlete and the competition schedule:

On a 7 day meet you'd try and get them racing on the majority of the days, given when their main events were. Whereas with the 4-day trials format no because it's too short, it's so compact and most of them have two events on a day. So you are trying to look for freshness rather than holding them through. (C12)

When a warm up swim is not a feasible option, for example at the Olympic Games where a swimmer has only qualified for one or two events, some coaches use broken swims, time trials or test sets, often in race suits, to replicate a heats and finals swim in the training environment. This work can take place anywhere between 2 and 10 days prior to their first race of the competition, allowing enough time to recover:

We'll do a rehearsal about 6 days before the meet, probably not the day before, where they've got to do a morning broken swim and an afternoon effort so it's a rehearsal of heat and final, whatever you want to call it. (C6)

Normally do a heat and a final, we put the suit on and hit it up and I change it, sometimes I go a 200 and a 200, sometimes 150 and 150, so they're not measuring themselves all the time. (C13)

We do that back-end speed test which is highly specific in staging, we've always done it in staging 3–5 days out of main event. (C7)

Competition: multiple main events

Most coaches plan the taper so the swimmer is ready for their first event of a competition even if it is not considered their priority event. Five coaches mentioned adjusting the timing of the taper to focus on the priority event irrespective of whether it falls on day 2 or day 7 of a competition:

It depends which event is the main event, but you rest up to do the event, say for example the best event is second I would focus on the second event. (C2)

A swimmer may have a 5–6 day gap between events and during this time most coaches include some recovery after the first race followed by reduced volume training incorporating race pace work, possibly a time trial or broken swim, to prepare for the next event:

If we race day 1 and we're not racing till day 5 or 6, day 3 I'll do a broken swim in the morning and a broken swim in the night to see if they can beat it. (C11)

I'll do a couple of little pace checks through the week. You develop a few little sets that you want them to do and I think just try to keep relaxed, it's nearly more of a mental thing you know. (C16)

Discussion

This study examined the current practices and philosophies of high-performance swimming coaches on methods of pacing entrainment and competition preparation. Coaches emphasised the importance of tailoring all elements of training and competition periodisation to suit the individual needs of each swimmer. There is no one size fits all approach, therefore coaches are constantly challenged to individualise their programs to get the most out of each swimmer within their squad. In terms of pacing skill development, it appears some coaches are not monitoring some of the key variables which may be important in the process of developing effective pacing behaviour.

The most common variables monitored during race pace-specific sessions include times, split times, SR and SC. The prevalence of SC monitoring may vary across strokes and one coach said, 'if they are a breaststroker then they always count their strokes'. This requirement may be related to the low mechanical efficiency of breaststroke and the high intra-cycle velocity fluctuations within each stroke, which is also observed in butterfly swimming.^{4,21} However, a number of coaches did not report monitoring some of these key variables which is surprising given that swimming velocity is a

product of SR and stroke length.⁴ While it can be challenging to monitor these variables in large groups, perhaps a greater emphasis should be placed on tracking SR and SC. The need to establish stroke efficiency early in the season was highlighted by many coaches as important, 'early season I'm all about rates and counts, so the efficiency'. Therefore, focusing less on overall times is likely beneficial at the beginning of the season. Having said that, given the importance of pacing in swimming,² it is imperative that split times are monitored and fed back to swimmers during race pace-specific sessions. Without feedback on splits, SR and SC, it is likely difficult for swimmers to develop pacing skills. Split time feedback may also be useful in aerobic sessions where swimmers are afforded the opportunity to hone their pacing skills during lower intensity swimming. Relatively few coaches reported monitoring split times, which may be related to the squad size and a lack of staff to assist. Although RPE was less commonly monitored, the use of this scale provides a simple and accessible tool for coaches to monitor perceived effort for a given pace. This tool could be beneficial in the development of pacing skills as the perception of effort likely plays a role in pace regulation.⁷

The prevalence of pacing aid use was relatively low, and while most coaches had previously used pacing aids, many were not using them at the time of the study. Pacing aids were perceived to be useful for specific strokes, events and types of sessions, for example race-specific sessions and for backstroke, breaststroke and distance freestyle swimmers. Some coaches only use a metronome to improve efficiency with swimmers who typically swim with a SR that could be too high or low to suit their event and individual characteristics. While the potential benefits of other pacing aids were acknowledged, many coaches favoured using a stopwatch, which can be a simple and effective tool. Coaches prefer their swimmers to be self-sufficient and are often discouraged from purchasing or using technology if it is expensive, requires time to set up and is unreliable, even if they think it may be helpful to their athletes. Although the market for swimming-based technology has increased markedly over recent years, it is only within the last ~5 years that reliable, swimming-specific products have been commercially available. As a result, coaches have created other ways to develop pacing skills in the pool, for example using games to improve a swimmer's ability to feel and judge differences in pace and SR. This method likely engages swimmers by creating a fun learning environment where they are challenged by the coach and creates an element of competitiveness among team-mates. Exploring the effectiveness of this approach and the time required to improve pacing ability would provide

useful and practically applicable information for coaches. As highlighted by one coach, it is likely that pacing skill development needs to start from an early age, although little is currently known about this process in developing youth athletes.²²

The frequency and content of race pace sessions within a training week appear to vary throughout the season. For example, session frequency and training volume at race pace may increase as the season progresses, which is attributed to a shift in focus to more race specific preparation. This periodisation of training load throughout a season is common across all sports and is designed to facilitate physiological adaptations while also minimising injury and preventing overtraining.²³ Given most swimmers compete across multiple events of varying distances and sometimes strokes, it can be challenging to balance the training program to ensure the needs of each swimmer are met. While many coaches allocate specific sessions to focus on one event at a time, others include elements of multiple events within the same session. The latter approach may be beneficial in increasing the regularity of practice in each event and developing the skill to switch paces with ease. However, this method may hinder the learning process for swimmers who have not yet acquired the necessary pacing skills. Closer to competition, these race pace sessions become highly specific to more accurately reflect the demands of the race itself. For example, executing the race specific pacing strategy in terms of split times, SR and SC and reducing the rest between repeat efforts. Broken swims and time trials can be useful to help achieve this race specificity in the lead up to a competition. Some coaches provide individual feedback to swimmers on split times, SR and SC during these sessions. Adding constraints such as pre-fatigue was also utilised by some coaches with the aim of creating a stressor where swimmers are required to execute their race specific strategy under fatigue. For this strategy to be effective, swimmers would need to be sufficiently conditioned to first achieve race pace without prior fatigue.

While the pacing profiles of elite swimmers in competition have been well characterised, there is a need for greater individualisation when determining a swimmers' optimal race strategy in relation to pacing.² Coaches acknowledged the need for race strategies to be tailored to suit the individual strengths and weaknesses of each swimmer. They use a wide range of information to help determine the most effective pacing strategy for each swimmer, although only two coaches mentioned involving the swimmers themselves in this decision-making process. This level of engagement likely increases athlete buy-in to the training process and provides a good learning opportunity especially for younger athletes. The individual needs and

characteristics of the swimmer are also considered when determining racing frequency. The opportunity to race may be limited due to location and accessibility of competitions, especially for Australian swimmers where international competitions require extensive travel. Generally, coaches believe it is important for swimmers to get frequent race exposure, however, there must always be a clear purpose for racing. In season, this is typically process driven, for example executing the desired SR, SC or pacing on a segment of the race. This approach reduces the emphasis on achieving a certain time, which may be impractical when a swimmer is not tapered and in the middle of a heavy training block. Swimmers may race alternate events early in the season to get race practice, then closer to the major competition, event selection becomes more specific to the swimmers' priority events. This sequence follows the same pattern as the evolution of the training prescription throughout the season where the specificity gradually increases.

The final challenge after the months of training and preparation are completed, is successfully executing the race plan at the main competition of the season. This can be one hurdle too many for some swimmers, where they are unable to implement the skills they have developed throughout the season under pressure. Warm up swims are sometimes used to manage nerves or increase familiarity with the environment when a swimmer's main event is not scheduled until later in the competition. As with all other aspects of training prescription and competition preparation, the use of warm up swims should be tailored to the needs of each individual and this strategy may have a positive or negative impact on subsequent performance. However, more commonly coaches use race simulations in training via broken swims and time trials. For example, rehearsal of a morning heat and evening final is a popular method to build the ability to race multiple times in 1 day with limited recovery time. Limitations of this method include the difficulty in replicating the competition environment in training, and the reliance on having swimmers of similar ability levels swimming the same events to create an element of racing and competitiveness. When a coach is planning these final preparations leading into competition, it is important that the taper is also individualised. The aim of a taper, which is a short-term reduction in training load prior to a competition, is to maximise performance.²⁴ The optimal duration of a taper is highly individual and can range from 4 to 28 days.²⁴ Coaches align the timing of the taper with each swimmers' competition schedule to ensure they are race ready for their first main event. Most swimmers typically race in two to three main events, although there may be one event that takes priority if, for

example, they have a better chance of achieving the selection criteria or winning a medal in that event. In this case, some coaches might adjust the timing of the taper to centre around being prepared for this priority event. There is a need to maintain fitness and race readiness on recovery days between races during a week-long competition, and coaches recognised the importance of considering both physiological and psychological factors in this process. While the main purpose of a taper is to improve performance by maintaining or enhancing physiological adaptations, a taper period could also reduce the impact of psychological stressors associated with daily training.^{24,25} This is difficult to quantify and coaches are often required to call upon past experiences and their extensive knowledge of each individual swimmer to determine the appropriate taper prescription.

Conclusion

This study provides novel insights into the existing practices of high-performance swimming coaches. While coaches are required to undertake professional development activities such as educational workshops, it appears that coach beliefs and practices regarding pacing are heavily influenced by previous experiences and the experiences of other coaches.²⁶ This is not surprising given the lack of scientific evidence currently available on pacing skill development in swimming.^{2,27} It appears that some coaches place too much emphasis on overall time as opposed to the process of achieving that time in terms of efficiency and race specificity. A perceived inability to monitor key pacing variables such as split times, SR and SC with large groups may inhibit pacing skill development, especially with young and inexperienced swimmers who are in the early stages of pacing skill development. While it can be difficult to individualise training prescription in large squads, it is vital that the individual needs of each swimmer are considered. As technology advances, pacing aids could assist coaches in the process of pacing entrainment and monitoring. The knowledge gained from this study can help inform the direction and design of future research in this area, and promote development of evidence-based guidelines on effective pacing entrainment methods in swimming.

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