Title: Warm-up strategies of elite triathletes competing in the International Triathlon Union World Triathlon Series and Paratriathlon events: A case study

Running head: Warm-up strategies of elite triathletes

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ABSTRACT

The use of a warm-up is a widely recommended and adopted strategy for athletes to optimise performance. However, limited recommendations about the optimal warm-up strategy for triathletes exist. Therefore, the purpose of this study was to investigate the warm-up strategies of elite triathletes in preparation for competition. Ten elite triathletes (n=6 female and n=4 male, age: 26.8±6.1 y) currently competing in the International Triathlon Union World Triathlon Series (n=8) or Paratriathlon Series (n=2) completed a survey about their warm-up routine. For the World Series athletes, the range in total warm-up duration was 25-55 min, which included 8-20 min of swimming, 0-30 min of cycling and 5-25 min of running. For the Paratriathlon athletes, the range of total warm-up duration was 15-25 min, which included 5-15 min of swimming, 0-10 min of cycling and 0-10 min of running. Elite triathletes finished their warm-up 13±5 min prior to race start. The inclusion of additional warm-up strategies varied in frequency: dynamic activation drills (7/10; 70%), short sprints (7/10; 70%), static stretching (5/10; 50%), technique drills (5/10; 50%), static muscle activations (3/10; 30%), foam rolling (2/10; 20%) and massage (0/10; 0%). There is a large range in the duration and intensities of the warm-up strategies amongst elite triathletes, which highlights the individual needs of the athletes and/or a lack of scientific recommendations available. Future research should be based on current practice to begin to develop an optimal warm-up routine for triathletes. Developing athletes can experiment with modified versions of current practice during training in scenarios simulating competition.

Keywords: *Preparation; routine; competition; elite; athlete*

INTRODUCTION

The use of a warm-up prior to competition is a widely recommended and adopted strategy for all athletes (Bishop, 2003). A range of different warm-up strategies have been beneficial to improve explosive performance for team sports (i.e. jumping, sprinting and agility tasks), including warm-up protocols involving repeated sprints, dynamic exercises, small-sided games and the application of heated garments (Silva, Neiva, Marques, Izquierdo, & Marinho, 2018). Warm-up strategies have also proven beneficial for swimming, cycling and running-based tasks, which has been attributed to temperature, metabolic, neural and psychological mechanisms (McGowan, Pyne, Thompson, & Rattray, 2015). However, much of the literature investigating warm-up has been criticised due to methodological issues, including: i) a low sample size, ii) untrained populations, iii) ecological difficulties of simulating competition scenarios (e.g. the delay caused by pre-competition marshalling), and iv) lack of and/or inappropriate statistical analyses (Bishop, 2003; McGowan et al., 2015). Hence, it has been suggested that warm-up routines of elite athletes are largely based on trial-and-error, rather than empirical evidence (Bishop, 2003).

Warm-up is considered to be important for elite triathletes due to the high physiological demands on the athlete at the start of the event as speed over the first 222 m of the swim leg was highly associated with finishing position (Vleck, Bentley, Millet, & Burgi, 2008). However, limited research on warm-up is available specifically for triathletes, with a single investigation demonstrating that a 10-minute swim or 10-minute run/swim warm-up did not significantly improve swim or triathlon performance (Binnie, Landers, & Peeling, 2012). Therefore, other strategies that may be effective require investigation. However, a challenge exists in research concerning triathlon where there are many possible amalgamations of warm-up (i.e. different durations of swimming, cycling, running, the distribution of intensity

and the timing prior to race start), researchers need an appropriate starting point that is applicable to athletes who are currently competing. Therefore, the purpose of this case study is to describe the warm-up strategies of elite triathletes, with the view that these athletes are likely doing something correct in terms of their warm-up practices, and the 'current practice' of these elite athletes represents an appropriate comparison for any new interventions that are to be investigated.

METHODS

Approach

An online survey instrument was developed to elicit information relating to the pre-event warm-up strategies and beliefs of elite triathletes. A letter of invitation and guidelines for the online survey (surveymonkey.com, California, Palo Alto, USA) were distributed electronically to individual athletes that currently compete in the International Triathlon Union (ITU) World Triathlon Series and Paratriathlon events. Also, letters of invitation were provided to professional coaches to encourage the participation of their athletes who met this inclusion criterion. Athletes were asked to report their name and race results, which were verified at www.triathlon.org/results and then de-identified prior to analysis.

Participants

Ten elite triathletes (n=6 female and n=4 male, age: 26.8±6.1 y) who currently compete in the ITU World Triathlon Series (n=8) or Paratriathlon Series (n=2) volunteered for the study. Participants had competed at this level for 1-10 years. The sample included both Olympic and Paralympic medalists. The Human Research Ethics Committee at the University of Newcastle granted approval for the project (H-2015-0305) and participants provided written informed consent prior to commencing the survey. There was no incentive to participate.

96

97 ***Procedures***

98 Participants completed 11 major items related to their pre-event warm-up strategies.
99 Participants were asked to indicate if they complete a warm-up and the average duration and
100 intensity of that warm-up separately for swimming, cycling, and running. Intensities were
101 defined as "very light-comfortable (low intensity)," "somewhat hard-hard (moderate
102 intensity)" and "very hard-maximal (high intensity; greater than anaerobic threshold)." Only
103 three intensity zones were included in order to minimise confusion and create a consistent
104 definition of intensity between participants. Participants were asked how long prior to an
105 event they aim to finish their warm-up and whether they include a range of common
106 additional strategies, including: dynamic activations, short sprints, static stretching, technique
107 drills, static muscle activations, foam rolling and massage. Further, participants were asked
108 why (or why not) they complete a warm-up and if any factors influence their normal routine.

109

110 ***Statistical Analysis***

111 As the present study is a descriptive cross-sectional survey design, the analysis and
112 presentation of data are descriptive.

113

114 **RESULTS**

115 The individual warm-up durations and intensity distributions of the triathletes are illustrated
116 in Figure 1. For the ITU World Series athletes, the range of total warm-up duration was 25-
117 55 min, which included 8-20 min of swimming, 0-30 min of cycling and 5-25 min of running.
118 The range of the intensity distribution of these warm-ups included 0-92% at a low intensity 8-
119 75% at moderate intensity and 0-25% at high intensity. For the ITU Paratriathlon athletes, the
120 range of total warm-up duration was 15-25 min, which included 5-15 min of swimming, 0-10

min of cycling and 0-10 min of running. The intensity distribution of these warm-ups included 59-100% at low intensity, 0-29% at moderate intensity and 0-12% at high intensity.

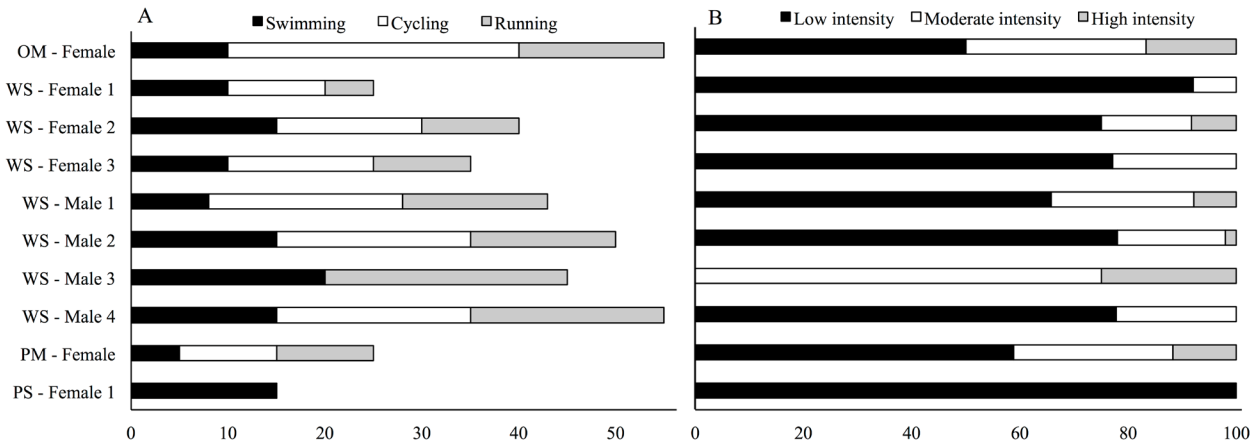

Figure 1. Individual triathlon-specific warm-up duration (A) and intensity distribution (B) for elite ITU world series triathletes (n=8) and paratriathletes (n=2)

Elite triathletes aimed to finish their warm-up 5-20 min prior to the race start. Additional strategies included in the warm-up were: dynamic activation drills (7/10; 70%), short sprints (7/10; 70%), static stretching (5/10; 50%), technique drills (5/10; 50%), static muscle activations (3/10; 30%), and foam rolling (2/10; 20%). No triathlete reported the use of massage in their warm-up routine. Commonly reported reasons to perform a warm-up included: to perform better (6/10; 60%), to increase blood flow (5/10; 50%), to increase energy production (4/10; 40%), to increase concentration (4/10; 40%) or to increase body temperature (3/10; 30%). Most triathletes noted that they would decrease the duration of their warm-up in the heat (8/10; 80%), however fewer triathletes would increase the duration in the cold (4/10; 40%). Time (8/10; 80%) and space (6/10; 60%) were factors that would influence a triathlete's warm-up strategy.

DISCUSSION

This case study has identified that all elite triathletes surveyed perform a pre-event warm-up, however, an important finding was the variation of the total warm-up duration and the intensity distribution of the triathlon specific warm-up activities. The varied approach to the warm-ups can be attributed to several factors. Firstly, these warm-up routines were likely developed specifically for the individual, to help prepare them physically and mentally. Secondly, there is limited research on triathlon specific warm-up protocols and subsequently, there are no empirical recommendations available about the effectiveness of different warm-up strategies for triathletes. Hence, the individual routines were likely developed through trial-and-error rather than on the basis of empirical research (Bishop, 2003).

The majority of the warm-ups for both World Series and Paratriathlon Series athletes are made up of low intensity activities, and 4/10 of the athletes do not include any high intensity activity in their warm-up. Previously, the inclusion of high intensity activity has significantly improved 100 m swim time (Neiva et al., 2014) and 800 m run time (Ingham, Fudge, Pringle, & Jones, 2013), however reducing the amount of high intensity activity has been shown to be beneficial for sprint cycling (Tomaras & MacIntosh, 2011). Furthermore, researchers have also reported the benefits of a low intensity warm-up compared with no warm-up at all (Zourdos et al., 2017). With these mixed findings, there are no clear evidenced-based guidelines for triathletes to use to prescribe their warm-up. However, warm-up recommendations exist for explosive performance, which include 10-15 minutes of cardiovascular exercise that gradually increases in intensity (to 50-90%), and the use of heated garments afterwards to maintain muscle temperature (Silva et al., 2018). Further, 2 minutes of re-warm-up including sprints is needed when the rest period is longer than

15 minutes. Hence, such a strategy may also be useful for triathletes who are required to perform an explosive swim start.

The majority of elite triathletes surveyed also perform dynamic activation drills and short sprints, which have been described as ergogenic (McGowan et al., 2015; Yamaguchi, Takizawa, & Shibata, 2015) and half practiced some form of technique drill as a part of their warm-up routine. The majority of triathletes also followed current recommendations to reduce the warm-up duration in hot conditions (McGowan et al., 2015). However, half of the triathletes employed the out-dated strategy of static stretching, which is not recommended prior to endurance exercise (Lowery et al., 2014; Peck, Chomko, Gaz, & Farrell, 2014; Wilson et al., 2010). Finally, two of the triathletes performed foam rolling and none received massage, which suggests that most of the triathletes do not feel that they gain benefits from these strategies.

The data presented should not be considered as an optimal warm-up. Empirical research is needed to determine if the warm-up strategies presented here are beneficial, and to identify how these strategies could be improved to optimise triathlon performance. Examples of potential future comparative studies based on the data derived from the World Series athletes in the current investigation are demonstrated in Table 1, where each variable should be investigated in a separate study. Trial 1 represents current practise - the outcomes of the current study. The other trials represent altered versions of current practise across five different variables to be examined individually, which may be useful warm-up interventions for future researchers to investigate. This research should apply a randomised cross-over design to investigate the effect of warm-up duration, intensity, timing and modality with foundations around current practice. The additional strategies incorporated by the athletes

such as drills, sprints and foam rolling also warrant investigation. Finally, future researchers should ensure that their performance tests are both reliable and valid, by implementing time-trial protocols, race specific hydration practices and incorporating appropriate facing wind speed (Stevens & Dascombe, 2015). Cycling ergometers that allow triathletes to use their own bikes (Novak, Stevens, & Dascombe, 2015) and treadmills that permit subconscious pacing strategies (Stevens et al., 2015) are also available to maximise external validity in the laboratory.

Table 1. Future research projects needed to optimise triathlon specific warm-up.

Variable to be Optimised	**Trial 1 (Current Practice)**	**Trial 2 (Novel Strategy 1)**	**Trial 3 (Novel Strategy 2)**	**Trial 4 (Control)**
Duration	15 min each of swimming, cycling and running	10 min each of swimming, cycling and running	20 min each of swimming, cycling and running	No warm-up
Intensity	Combination of low intensity (65%), moderate intensity (28%) and high intensity (8%)	Low intensity activity only	Combination of low intensity (70%) and moderate intensity (30%) only	No warm-up
Timing	Warm-up completed 13 min prior to race start	Warm-up completed 8 min prior to race start	Warm-up completed 18 min prior to race start	No warm-up
Modality	Include swim, bike and run	Include swim only	Include swim and bike only	No warm-up
Additional strategies	Include dynamic drills	Include static activation drills	Include foam rolling	No warm-up

Due to the limited literature regarding the effects of warm-up on triathlon performance, and the likely individualised trial-and-error approach adopted by most athletes, developing triathletes should not blindly copy the practices of the elite athletes reported within this study. Instead, they should consider these strategies relative to what is practical in their situation,

but they should ultimately work with their coach to optimise their individual regime when training in simulated competition scenarios.

The current study is limited by a small sample size, as a trade off exists between quality (i.e. elite level) and quantity of recruitment. Other elite triathletes not included here may perform different warm-up routines, however, the current case study does provide a snapshot of the current practice of some elite ITU triathletes. The study is also limited by the participant's interpretation of our descriptors of the intensity categories used. Three categories were chosen with perceived exertion descriptors to assist with understanding and to minimise confusion.

This study has identified that all of the elite triathletes surveyed perform a pre-event warm-up, but variations exist within the total warm-up duration and the intensity distribution of the warm-up activities, likely due to a lack of empirical evidence and recommendations available. Approximately half of the athletes incorporate high intensity activities, while half perform low-moderate intensities only. Most of the athletes follow recommendations to incorporate dynamic activations and short sprints in their warm-up. Future research should aim to provide specific recommendations for triathletes that are relevant to elite athletes by incorporating current practice into original research.

PRACTICAL APPLICATIONS

Researchers investigating the effects of warm-up in triathletes should make comparisons to the practice of elite athletes, as well as experiment with variations on current practice (as per Table 1). Until this research is available, coaches with developing athletes should experiment with various versions of current practice (as per Figure 1) in training scenarios that simulate

235 competition. It is vital that the chosen warm-up routine is thoroughly tested and deemed
236 effective by the athlete to maximise the belief and confidence gained prior to the event.

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