Sports Medicine and Health Science 3 (2021) 207–211

Contents lists available at ScienceDirect

Sports Medicine and Health Science

journal homepage: www.keaipublishing.com/en/journals/sports-medicine-and-health-science/

Review

Swimrun race, athletes, safety and performance: A brief review

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A R T I C L E I N F O

Keywords:
Swimrun
Athletic performance
Cold water swimming

A B S T R A C T

Swimrun was established in Sweden in 2006. In competition athletes alternate between running and swimming multiple times. It has grown from only being hosted in Sweden to now being a global sport. The swimrun race exposes athletes to environments that require a unique set of skills. For example, participants have to negotiate ocean currents and waves. The environmental conditions change between the runs and the swims. Athletes may be exposed to hot temperatures when running in wetsuits (25 °C and hotter) and cold water (colder than 16 °C) when swimming. This sudden change in environmental conditions imposes a poorly defined physiological stress on the participants. Research on the demands of swimrun is scarce. More research is needed to improve athlete safety during events. Also, research is needed to provide insight into enhancing training methods and performance.

Introduction

Swimrun is a sport in which athletes alternate multiple times between running and swimming. The sport originated in Sweden in 2006, but now takes place internationally.[1] The number of participants, races, and competitiveness has increased progressively. It has been reported that the growth of Swimrun currently is larger than that of triathlon in the early 2000s.[2] Although the races attract high-profile competitors who compete for prize money, the research on swimrun is scarce[3,4] and in general, not much is known about the physiological demands of this sport (Fig. 1). It was reported in 2018 that the winners of a special ÖtillÖ Golden Bib category won EUR 33000.[5]

Therefore, the scope of this review is to explore the race format, analyze the existing literature on swimrun, identify unique challenges in this race and discuss ideas for future research.

Swimrun race format

Swimrun is a race in which competitors usually race with a partner. The categories are either male, female or mixed. Participants race together and may not be separated by more than a certain distance at any point during the race (this distance may vary depending on the race). A few races do not require competitors to have a partner. These races are either in still-water (for example, lakes) and/or are of short distance.

Competitors have compulsory equipment, which is defined depending on the race but usually consists of a wetsuit (if a cold water swim), a swimming cap, an event vest and running shoes. Goggles, hand-paddles, flotation buoys and tether ropes are optional.

The race consists of multiple segments of running and swimming, hence the name "swimrun".[6] The distance of each of these segments varies depending on the race. Events can be considered as ultra-endurance races, such as the ÖtillÖ World Championship (10 km swimming, 65 km running),[7] or they could be short, for example, the Cape Val de Vie race (2 km swimming and 9 km running).[8] The swimming segments mostly take place in the ocean and the running segments vary between road, trail, unmarked trail, etc. Due to this, there is always large variability in the terrain, weather, and ocean conditions the competitors will be exposed to.

Swimrun races have unique demands compared to other endurance sports such as aquathlon and triathlon that combine swimming and running. Firstly, swimrun differs from both in that athletes are required to race in all their equipment at all times i.e. run in their wetsuits and swim caps and swim with their running shoes on. Aquathlon athletes and triathletes are not required to do this and as such make use of transition stations to change race clothing. Secondly, the rules permit swimrun athletes to swim with hand-paddles, buoys and use tether ropes (tied between partners so that the stronger athlete can pull their partner during a segment if needed). Thirdly, in aquathlon and triathlon, there is only one swimming and one running segment, whereas in swimrun, there have to be at least two segments of both running and swimming. Fourthly, in triathlon there is the cycling leg, which is absent from swimrun.

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https://doi.org/10.1016/j.smhs.2021.10.002
Received 29 April 2021; Received in revised form 5 October 2021; Accepted 8 October 2021
Available online 21 October 2021

List of abbreviations

RPE	rating of perceived exertion
DNF	did not finish
VO_2max	maximal oxygen consumption
CON	control group
ANX	intervention group

Existing literature on swimrun

The following keywords were used in a search of the literature: “swimrun”, “swim-run”, “swimrunners”, “swimming and running” (in conjunction with one another). Searches were performed on various platforms including PubMed, Scopus, Google Scholar, Science Direct, PRIMO and Ovid. Only two scientific papers on swimrun were retrieved using these criteria.

The first paper published on swimrun is an intervention study that assessed the effect of mental imagery and motivational self-task training on the rating of perceived exertion (RPE) and flow state during a swimrun race.[3] Flow state, as described by the authors of the paper, is a “positive experiential state, which occurs when the performer is totally connected to the performance, in a situation where personal skills equal required challenges". The authors used swimrun as a sport modality because they wanted to test their intervention on people participating in a "really tough" endurance race. They recruited 22 males who had raced in at least one swimrun race. Eleven males were randomly assigned to either a control group (received no mental training) or to an intervention group (received mental training). They hypothesized that receiving additional mental training would result in a better overall race experience (lower RPE and better flow state). Both groups had two physical training sessions a week for eight weeks before the swimrun race. The physical training sessions were tailored to each participant’s percentage of maximum heart rate. The intervention group also did several 60-min-long sessions of mental imagery and motivational self-task training for a month leading up to the swimrun race. After the swimrun race, the authors measured RPE and flow state. A flow state can be measured by using a validated questionnaire, called a Flow State Scale. The authors found that the intervention group reported a significantly lower RPE and a significantly improved flow state after they completed the race. They concluded that mental training is a useful tool in improving race experience, however, they admitted they did not control for a placebo effect (the control group received no placebo training instead of the mental training). In addition to this, the authors did not report the average race times of the two groups, therefore it is unknown whether the mental training benefitted the performance of the intervention group or not. They also did not show whether the two groups were performance-matched at the start and end of testing. It would also have been beneficial if the terrain of the swimrun race was described because it would be useful if this mental training helps for "flat" racing or more environmentally challenging racing.

The second paper was an observational study that aimed to assess the race times and participation in swimrun over four years.[4] In this study, the race time and participation data of five races from 2012 to 2016 in the ÖtillÖ world series were used. Linear regression analysis showed that on average the male teams decreased their overall race times by 17 min/year, the mixed teams 40 min/year and the female teams 59 min/year. The authors concluded that these large performance gains were due to increased race experience. However, the study design only used the top three winning teams of each year. Due to the sport being relatively new, there is a good chance that in each year there were more new professional participants, which contributed to the gains in performance. When pooling all participation data, they found that the male teams made up 66% of races, mixed teams 23% of races, and female teams 11% of races.

The study also showed the number of people who did not finish (DNF) races varied from 4% to 33% of race participants.[4] The race in which the highest DNF took place (33%) was a race in Germany where the water temperature was about 10 °C and the air temperature was 5–10 °C. These cold conditions could be dangerous for race participants. The safety guidelines for minimum water and air temperatures in swimrun have not been set. This is important because, with the swimrun sport being new, athletes that compete may not have a cold open-water swimming background in water as cold as the race recorded in Germany. That is evident in the race with the lowest DNF rate (4%) which was the ÖtillÖ World Championship. Participants had to qualify for this race and were thus all experienced. In conclusion, the performance gains that have occurred will likely plateau as more race experience is gained and there is an increased (and more constant) participation in races.[4]

Fig. 1. Priori factors of performance in swimrun. Factors that may influence the performance of a team during a swimrun race, which have been separated into external and internal factors.

"Extreme" thermoregulation: safety first

As with most sports, the safety of the competitors needs to be considered. In swimrun races, there are first aid stations, medical staff and water safety personnel. However, no research has been conducted on the risks associated with the race. Therefore, it is difficult to know which symptoms are hazardous to athlete safety in this sport. As with other endurance sports, participants could experience exercise-associated symptoms of exhaustion, cramping, hyponatraemia, dehydration and hyperthermia or hypothermia).[9–13] However, swimrun has unique demands that are not present in other sports, in particular the effect of alternating between running and swimming multiple times. This can be challenging when swimming in cold (±12 °C) water and running in warmer air temperatures (±25 °C) wearing a wetsuit.

The physiological responses to both heat and cold exposures have been studied.[14,15] When exercising in the heat, the body responds by vasodilating vessels near the skin, increasing sweat loss, usually an increased cardiac output and behavioural changes.[15] In contrast to this, being exposed to the cold results in decreased blood flow to the skin via vasoconstriction, an increased metabolic rate to produce more heat and eventually shivering.[14] The body usually adapts to different temperatures in healthy athletes, however, the response can be altered if an athlete has performed prior exercise.[16] Castellani et al. found that prior exercise resulted in a blunted response to adapt in cold temperatures, known as "thermoregulatory fatigue".[16] In their study, ten males underwent two treatments on different occasions before being exposed to cold air for 2 h. The first treatment was to cycle for 60 min at 55% VO_2max (maximal oxygen consumption) before cold air exposure, and the second treatment was to be passively heated (resting in 38 °C water) before being exposed to cold air. The authors found that exercising before cold exposure resulted in a significantly lower mean rectal temperature during cold air exposure (from the 40th minute until the end of the 2 h) and greater heat loss compared to passive heating (not exercising before cold exposure). This is important when considering swimrun because before each swimming bout (cold exposure), athletes have completed a running section (and as the race goes on, each swim is preceded by an increasing number of swims and runs) which could lead to a blunted response to cold exposure. There are two implications of this: firstly, this raises concern for participant safety, and secondly, this alters performance as colder core temperatures result in poorer performance.[17] The latter presents itself as a potential aspect that could be improved by specific training to enhance performance during a swimrun.

Interestingly, swimming-related problems are not always a result of hypothermia. It has been suggested that sudden deaths during open-water swimming could in part be due to an abnormal cardiac event known as "autonomic conflict".[18] After the first exposure to cold water, the autonomic nervous system is influenced in two ways.[17] Firstly, cutaneous cold receptors respond to the cold temperature by inducing a cold shock response, via the stimulation of the sympathetic nervous system. The cold shock response is characterized by hyperventilation (leading to hypocapnia), increased heart rate and inspiratory gasps.[19] Secondly, at the same time, facial cooling and wetting lead to a diving response via the parasympathetic nervous system. This is associated with bradycardia, apnoea and vasoconstriction in the limbs and trunk.[20] The two responses have conflicting effects on the heart, hence the term "autonomic conflict". This has been linked with cardiac dysrhythmia and arrhythmias, which are risk factors of sudden cardiac arrest.[21] Athletes with cardiac pathologies would be at higher risk of this occurring.

Is fitness everything?

Performance in the swimrun is influenced by an athlete's terrain experience, particularly because of the variable outdoor environment in which swimrun races occur.[4] Lepers et al.[4] were limited in their assessment of the contribution of terrain experience because no tool exists to measure an athlete's knowledge/experience about the swimrun race environment. An example where individuals have to be tested on their performance in and knowledge about the ocean is surf (beach) lifeguards. Due to the currents and waves that swimrunners are required to face in races, the closest sport where ocean ability is formally tested is surf lifesaving.

Tipton et al.[22] studied the effect of prior exposure to the ocean on swimming performance. The sample group included 35 surf lifeguards (with ocean experience) and 30 pool lifeguards (no ocean experience). The best effort of the lifeguards in the 200 m swim in the pool, calm sea, sea with surf (waves present), underwater swim test, and 30 s swim bench test were measured. The mean swimming times in the pool and calm sea were similar, however, the surf lifeguards had a significantly faster mean 200 m surf swim time than the pool lifeguards. All other measurements, including anthropometrical characteristics, were similar. When all the measured factors were considered, the strongest performance predictor of a surf swim was ocean experience ($R^2 = 0.32$; $p < 0.01$). The authors concluded that experience in the ocean had a detectable difference in surf swimming. However, the authors did not define what they meant by experience, which could be linked to anything including thermal habituation, control over anxiety, a learning effect of swimming through currents or waves, or a combination of these.[22]

Physiological adaptations can be achieved in response to being exposed to hot and cold environments. Heat acclimation improves exercise performance in the heat[23,24] and repeated cold water immersions improve exercise performance in the cold. The latter is a result of improved thermogenesis and decreased cold sensation, but interestingly the adaptation has been found to be greater when repeated cold water immersions are done statically (resting) rather than exercising in the cold.[25] Repeated cold water immersions can save as much as 20% total heat production, compared to when no habituation has occurred. This would most likely affect endurance performance.[26] An example of this having been done in the past is Lewis Pugh's preparation for his world record swim in the North Pole. He prepared in advance by submerging himself repeatedly in ice water (2 °C). He would swim in this water for about 15–20 min per session four times a week.[27]

Habituation in the cold can also affect the cold shock response, which is related to athlete safety. Barwood et al.[19] studied the effect of various cold-water immersions on the cold shock response and how anxiety relates to this. The reason for this is because of the safety hazard implications of the cold shock response when doing cold water swimming: increased respiratory rate (hypocapnia), increased heart rate, confusion, disorientation, and a large inspiratory gasp that could result in aspirating water.[17] In this study, two tests were performed.[19] In the first test, 11 participants were subjected to two water immersions in random order. The one immersion (labelled control, "CON") was at 15 °C for 7 min and the other immersion (labelled anxiety, "ANX") was also at 15 °C for 7 min, but the participants were deceived beforehand that the water was 5 °C colder even though the temperature had not changed. In the second test (ten people remained) the participants underwent seven repeated cold-water immersions, but in immersions six and seven, anxiety was stimulated the same way as in study 1. In both studies, anthropometry, anxiety (on a 20 cm scale), cardiac frequency, respiratory frequency, tidal volume, and minute-ventilation were measured. It was found that in study 1 (ANX versus CON group responses), just being told that the water was colder than it actually was resulted in the ANX group having significantly higher levels of anxiety, and higher cardiac frequency and minute-ventilation. In study 2 (repeated immersions), it was shown that repeated immersions lead to a decreased ventilatory response compared to their original cold shock response, but the increased cardiac frequency had not changed. This study showed two things. Firstly, there is a strong mental component when being exposed to cold water that is unrelated to the actual temperature of the water. If that can be trained, then that would already make swimming safer (decreased volume of air breathed in results in a lower chance of aspirating saltwater). This is particularly important in the context of swimrun, where athletes are subjected to several cold-water immersions, thus experiencing several cold shock responses. Being prepared in advance would likely lead to safer race conditions. Secondly, the study showed that repeated immersions decrease the effect of the cold shock response. The mechanism of whether it is due to mental training, or physical adaptation is unknown because it was not measured. However, both results relate to ways of gaining experience, which could affect both race safety and performance, which are worth considering for swimrun.

Implications of the unique demands of swimrun

As mentioned previously, swimrun is a unique sport as it differs from other endurance sports in several ways: having to race with a partner, the kit that is worn, environmental exposures and the format of the race. All these factors can affect performance. For example, racing with a partner means that the pace is determined by the slowest partner in the team. It is, therefore, necessary to have careful planning between partners before races to ensure the strengths and weaknesses of the partners are synchronised. The reason for racing with a partner is primarily for safety reasons, but it also adds an interesting aspect to this race. The positive aspects of racing with a partner are that the partner can provide slip-streaming benefits in certain segments of the race and provide motivational support.

Recently, training options have become available for swimrun athletes. Mainly in Europe, swimrun coaching has become more established to prepare prospective athletes specifically for swimrun. One of the most popular options in Sweden is Envol Swimrun.[28] They provide personalised or group running and swimming programmes using applications such as Training Peaks to monitor athletes. The training programmes are likely based on triathlon, running and swimming research as no training research in swimrun exists yet. However, despite the advances in swimrun training, it would be beneficial to provide athletes with modern training strategies. This would include constructing programmes based on internal markers of cardiovascular fitness, such as VO_2max (would require lab testing),[29] heart rate zone tests[30] during running and swimming, and swimming tests[31] (timed swim sets, distance per stroke tests, lactate testing if available). Using these values could inform coaches to create more effective training strategies, keeping in mind the swimrun race being trained for: terrain type, running:swimming ratio, total distance and partner selection. Measuring internal markers are also important for detecting whether the athlete response to training is positive.

Racing with the same kit throughout the race also impacts performance. Although there is a racing kit designed specifically for swimrun,[32] compromises have had to be made for the kit to be able to be worn when running and swimming. For example, wetsuits have to be sufficiently thick to keep racers warm during swims; however, if they are too thick, they could restrict movement in running and also be heavier than normal running clothing. Shoes have to be worn for running, however, they would alter the foot shape and buoyancy during swimming, and thus may affect the biomechanics of kicking during swimming.

The environment also poses unique difficulties. Most swimrun races will not be cancelled if the weather is adverse (for example large waves, cold temperatures and strong winds). This was shown in a swimrun race referred to previously in Germany where the DNF rate was 33%.[4] Therefore, it is necessary to train in the same or similar environmental conditions to prepare for any condition in racing. However, the details of the training breakdown for swimrun have not been researched leaving many unanswered questions.

As Lepers et al.[4] explained, there are large performance gains in the sport at present, but those gains will eventually plateau. To further improve racing performance, it is pertinent to eventually investigate swimrun specific training strategies rather than using strategies from aquathlon or triathlon.

Future direction and conclusions

There are many unknowns about racing safety, the effect of swimrun exposures on athletes and predictors of performance including the impact of apparel on performance. Also, the details about training specifically for swimrun are not established.

Swimrun currently is undergoing growth making the need for research more relevant. This is necessary for racing to become safer from an organizational perspective and for athletes to adopt training strategies to allow both safer and faster racing. Open-water swimming consists of approximately half of the total time of a swimrun race but is generally under-researched due to the difficulty in creating research tools and protocols that can withstand the variable environment. Therefore, there is a need to create tools and protocols to study this field before swimrun specific questions can be researched.

Generally, the initial step in conducting research would be to characterize the various races and athletes. This would help with other research questions, including determining what the predictors of performance are in swimrun races, and how much each predictor influences race outcomes.

Specifically, with regards to athlete safety, it would also be useful to know what the effects of repeated cold shock exposures are in swimrun athletes and the effects of other environmental exposures as these have not yet been determined. There are many aspects that relate to the experience or knowledge of the race that can influence an athlete's safety and performance. It would be useful to construct tools to measure these different aspects separately. It is in the interest of both beginners and elite competitors to know more about these factors. Firstly, the information will make racing safer, and secondly, the information may convert into performance gains. These performance gains are distinguishable from the performance gains associated with fitness or endurance training.

This suggests that it would be important to improve health screening in the entry forms before the race and provide more information to race participants. Health screening could be done by asking athletes, as part of the online race entry, to check off a list if they suffer from any conditions known to be health risk factors when doing a race. Information regarding the risks of completing such a race could be published online and be e-mailed to all entrants.

Monitoring the body temperature changes between cold water immersions and running in wetsuits could be studied by using ingestible telemetric pills.[33] More research topics will emerge after initial studies are conducted. This would allow the growth of the sport, which would lead to more financial support from sponsorships to sustain races and research.

Submission statement

We confirm that this work is original and has not been published elsewhere, nor is under consideration for publication elsewhere.

Authors' contributions

Christina Geromont is the primary author of this paper. Associate Professor Andrew Bosch and Professor Mike Lambert guided the review process and edited the manuscript.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The investigator was financially supported by the University of Cape Town (Postgraduate Publication Incentive Fund).

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