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RESEARCH ARTICLE **Open Access**

Influence of age and sex on pacing during Sprint, Olympic, Half-Ironman and Ironman triathlons. Part B

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Abstract

The aim of this study was to investigate the influence of biological sex and age on the pacing strategies adopted by non-drafting top triathletes during the cycle and run disciplines of a Sprint, Olympic, half-Ironman and Ironman triathlon. Split times of the top 20% non-elite males (n=468) and females (n=146) were determined using official race transponders and a video capture system for pre-determined sections of the cycle and run disciplines of four triathlon distances. Indices of pacing were calculated to compare between sexes and age-groups. Results of this study indicated that different pacing strategies were adopted between athletes of different age and sex over the various triathlon disciplines and distances. Females were more aggressive during the initial stages of the cycling discipline across all distances (sprint - 2.1% p=0.024; Olympic - 1.6%, p=0.011; half-Ironman- 1.5%, p<0.001; Ironman - 1.7%, p<0.001 higher relative to mean) compare with males. Younger athletes (20-29 y) tend to begin the run faster (2.0 to 3.0% faster than other age-groups, p<0.029) during the sprint, Olympic and half-Ironman triathlons. These results indicate that different pacing strategies are adopted by non-drafting top athletes of different age and sex. Optimal pacing strategies may differ between sex and ages; therefore individuals may need to trial different strategies to develop their own optimal pacing profile for triathlon events of varying distances.

Keywords: Gender, ageing, cycling, running, pacing strategy

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Introduction

The optimisation of pacing during triathlon is a challenging task, due to the difficulty in successfully negotiating different disciplines (i.e. swim, run and bike) as well as the overall event (Bentley et al. 2002). Previous research examining pacing in triathlon has focused on draft-legal Olympic distance triathlons (~2h, Bernard et al. 2009; Le Meur et al. 2009; Vleck et al. 2008), with only a single study examining cycling pacing during the longer non-drafting Ironman distance (8-17 h, Abbiss et al. 2006). As such, the distribution of pace throughout the sprint (~1 h), half-Ironman (~5 h), and to an extent Ironman events are yet to be fully identified. It is likely that different pacing strategies could be adopted due to the influence of factors such as energy substrate demand and availability (muscle and liver glycogen), thermoregulation (Noakes et al. 2005), mental fatigue (Marcora et al. 2009), impaired muscle function and recruitment (Noakes et al. 2005), and the complex feed-forward cognitive control of the brain based on the expected duration of the event (Noakes et al. 2005; St Clair Gibson et al. 2006; Tucker and Noakes 2009).

Based upon previously published observations in Olympic distance triathlons, it appears that elite athletes typically adopt a positive pacing strategy (characterised by a progressive decrease in power output/or speed) during the swim, cycle and run disciplines (Le Meur et al. 2009; Vleck et al. 2006). For instance, Le Meur et al. (2009) observed a more pronounced decrease in the cycling speed for males (16.8%) compared with females during the first half of the cycling discipline in a World Cup Olympic distance triathlon. These results indicate that males may have adopted a more aggressive pacing strategy during the triathlon when compared with their female counterparts. Nevertheless, the draft-legal nature of these studies (Bernard et al. 2009; Le Meur et al. 2009; Vleck et al. 2008), along with a greater number of overall male competitors is likely to have highly influenced the pacing strategies adopted. To date, we are unaware of any studies that have yet examined gender differences in pacing strategies during the other three common (sprint, half-Ironman and Ironman) triathlon distances.

Table 1. Average ambient temperature, relative humidity and wind speed for the sprint, Olympic, half-Ironman and Ironman distance triathlons.

Distance	Measurement Time (hr)	Temperature (°C)	Relative Humidity (%)	Wind Speed (km·h^{-1})
Sprint	0900	21.0	46	17
Olympic	0900	28.4	64	13
Half-Ironman	0900	14.7	72	19
	1500	20.8	44	9
Ironman	0900	17.3	70	26
	1500	23.5	43	22
Mean±SD		21.0 ± 4.8	56.5 ± 13.6	17.7 ± 6.1

Whilst studies have observed an age-related decline in male and female triathlon performance (Etter et al. 2013; Lepers and Maffiuletti 2011; Lepers et al. 2010), the influence of advancing age on pacing adopted during a triathlon has not been investigated. The decline in performance beyond 50-55 years of age (Lepers and Maffiuletti 2011; Lepers et al. 2010) has been attributed to numerous physiological alterations, including reductions in muscle mass (sarcopenia), changes in muscle typology, lower resting muscle glycogen content, altered training and reduced training stimulus (Lepers et al. 2010), decrease in lactate threshold and reduced maximal oxygen uptake with advanced ageing (Lepers et al. 2013; Lepers and Maffiuletti 2011). Since all of these factors are associated with fatigue, they could, to various extents, influence the distribution of self-selected pace by triathletes of different ages.

Due to the lack of data elucidating the pacing strategies during non-drafting triathlon races of various distances in males and females across different age-groups, the aim of this study was to examine the effect of biological sex and age on pacing strategies adopted during the cycle and run disciplines in the sprint, Olympic, half-Ironman and Ironman distance triathlons. Results of this study could help to optimise triathlon performance in athletes of varying age and biological sexes.

Materials and methods

Speed during the bike and run sections of the top 20% age-group male and female participants (≥18 y) in a sprint (n=245 and 95 for males and females, respectively), Olympic (n=265 and 80), half-Ironman (n=905 and 335) and Ironman triathlon (n=925 and 220) were examined (detailed description of participants and triathlons found in Part A of this study). All competing athletes were monitored, however, only non-drafting athletes were selected for data analysis due to the influence of drafting which is allowed in selected elite races which could dictate pacing. No guidelines were given to participants regarding pacing and diet intake prior to and during the race. All swims were performed in open water. Prior to data collection, ethical clearance was obtained from the Edith Cowan University human research ethics committee, in accordance with the Australian National Statement on Ethical Conduct in Human Research, and complied with the ethical standards of JSC (Harriss and Atkinson 2009).

Performance times were determined by means of official race transponders. Additional splits of equal distance were obtained with a video capture system (Sony HDRHC9, Japan) recording at 25 Hz. The number of splits was determined by the closest denomination from distance for each race. A total of five cycle splits (S1 to S5) were obtained for the sprint and Olympic distance, while six (S1 to S6) were determined for the half-Ironman and Ironman distance. During the run discipline, five splits were obtained for the sprint distance, while six were measured for the Olympic, half-Ironman (HIM) and Ironman distance. The location and distance between each point was determined by a global positioning system, with an accuracy of 2-3 m (5 Hz, Wi SPI, GPSports, ACT, Australia).

Ambient temperature, relative humidity, wind direction and speed for each race (Table 1) were obtained from the Bureau of Meteorology as an average of a 10-min period before 9:00 a.m. and/or 3:00 p.m.

Based on the official timing and video capture system, the elapsed time for the respective splits during the cycle and run discipline and the entire course were determined for each participant in each race distance. The mean speed for each split was calculated as the distance covered divided by the completion time of each split. In order to examine pacing differences amongst top athletes and to account for the unequal sample sizes in each race distance, only the top 20% of overall finishers in each age and sex group were analysed. Participants were separated between sex and into 10 y age-groups (20-29, 30-39, 40-49, and 50+ y) to allow the detection of meaningful differences. A pacing index (IP), calculated to allow comparisons between age and sex, was defined as the mean speed of each split normalised to the mean speed of the entire discipline for each individual (Le Meur et al. 2011). IP allows direct comparisons between biological sexes and age separately, and was calculated as:

IP = *Mean speed of split / Mean speed for entire discipline of the individual*

Statistical tests were conducted using PASW Statistics (version 18.0, Chicago, Illinois). IP for each split were compared between sex and age-groups using a multi-variate analysis of variance (MANOVA). Where significance was detected, a Tukey's post-hoc test was used to determine where the differences lie. Alpha level was set at $p<0.05$. All results expressed as mean ±

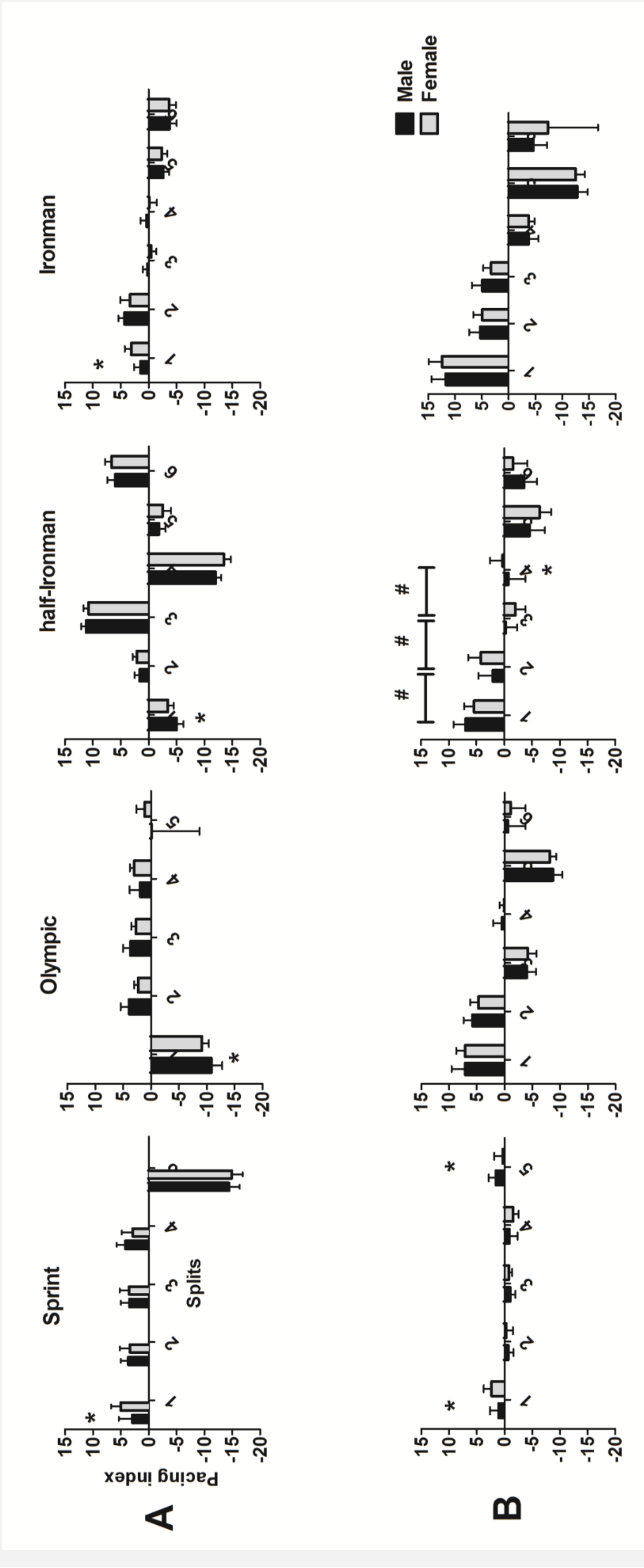

Figure 1. Pacing index across splits for males and females during the cycle (A) and run (B) disciplines of a sprint, Olympic, half-Ironman and Ironman triathlon. *different for pacing index, #different for index of variability in speed, p<0.05.

standard deviation (SD). No statistical comparisons were performed between race distances and disciplines due to: i) different participants between races, ii) dissimilar environmental conditions (temperature and wind speed/ direction) which could alter pacing, and iii) inconsistent splits distances between races and mode of locomotion. However, appropriate comparisons between races and disciplines were made, where necessary.

Results

Comparison between sexes during the cycle discipline revealed a lower IP in males for S1 during the cycle discipline across all four triathlon distances (sprint - 2.1% difference, p=0.024; Olympic - 1.6% difference, p=0.011; HIM- 1.5% difference, p<0.001; Ironman - 1.7% difference, p<0.001, Figure 1). IP at S4 was lower for females when compared with males (1.5%, p<0.001).During running, a lower IP was observed in males for S1 (1.3%, p=0.034) during the sprint distance. However, a higher IP was seen in S5 (1.2%, p=0.039).

Analysis of age-related changes showed an increase in IP in 50-59 y at S4 (3.0% higher than 20-29, p=0.031), followed by a decrease at the end of the cycle discipline (3.4% lower than 20-29 y, p=0.036) at S5 during the sprint distance cycle (Figure 2). During the HIM cycle, an initial age-related difference in IP was observed in 30-39 y, eliciting an IP closest to the mean at S3 and S4, compared with other age-groups. Specifically, the IP was lower at S3 (1.0%, p=0.009 and 1.1%, p=0.012, compared with 20-29 and 50-59 y, respectively), followed by a higher IP at S4 compared with all other age-groups (0.9%, p=0.043, 1.7%, p<0.01, 1.7%, p=0.002 compared with 20-29, 40-49, and 50-59 y, respectively). During the Ironman cycle, the 30-39 y age-group demonstrated a lower (closest to the mean speed) IP at split 1, compared with 50+ y (1.4%, p=0.029). During the run, a higher IP was observed in 20-29 y in S1 for the sprint (3.0% higher

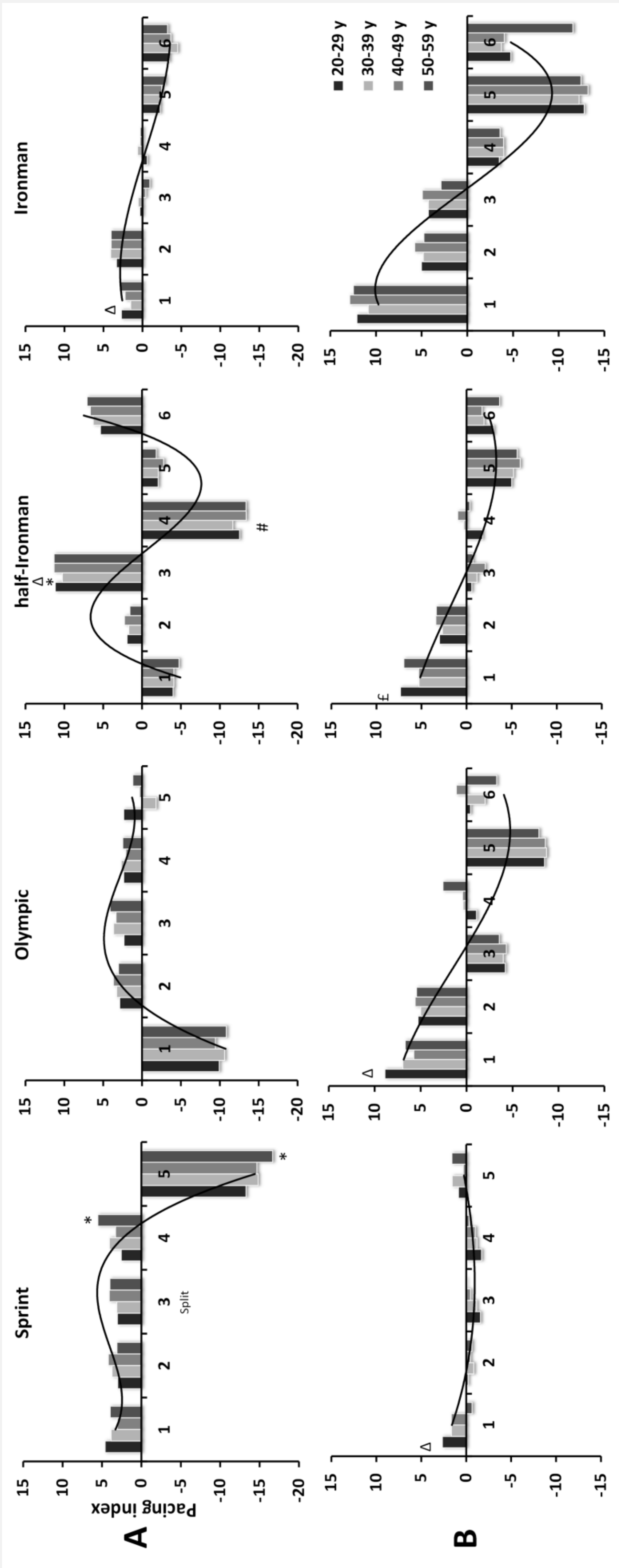

Figure 1. Pacing index across splits for the 20-29 y, 30-39 y, 40-49 y, and 50+ y age-group athletes during the cycle (A) and run (B) disciplines of a sprint, Olympic, half-Ironman and Ironman distance triathlon. *different from 20-29,£different from 30-39, ^different from 40-49,∆different from 50-59,#different from all other age-groups, p<0.05.Solid lines represent the polynomial trend (3rd power) for each split.

than 50+, p=0.008), Olympic (3.2% higher than 40-49, p=0.028) and HIM (2.1% higher than 30-39, p=0.01) distance. No significant differences were observed between age-groups for IP during the Ironman run.

Discussion

The aim of this study was to investigate the effect of biological sex and age on pacing strategies adopted by the top 20% age-group triathletes during cycling and running in the sprint, Olympic, half-Ironman and Ironman distance triathlons. Indirect comparisons between distances have been made with caution due to the influence of external conditions such as wind and topography during different triathlon distances. The main finding of this study was that the distribution of pace differed between sexes and age-groups over the various race distances and disciplines. Specifically, i) females commenced the cycle discipline at relatively faster speeds when compared with males throughout all four triathlon distances, ii) 30-39 y athletes demonstrated a more even cycling pacing strategy during the half-Ironman (compared with all other age-groups) and Ironman (compared with 50-59 y), iii) 20-29 y athletes started the run, during the sprint, Olympic and half-Ironman events, at relatively faster speeds when compared with all other age-groups, and iv) pacing strategies adopted during the cycle and run discipline were different from the overall pacing strategy adopted for the entire event.

The distinction of this study from past research is the non-drafting nature of the races. Cycle pacing during draft legal races is highly dictated by other competitors based on dynamic changes in tactical strategy (Bernard et al. 2009; Bernard et al. 2007) or attempts to bridge gaps with faster cycle packs (Le Meur et al. 2009; Vleck et al. 2008). Whilst non-drafting pacing could be influenced by the performance of other competitors, non-drafting races do not allow the formation of cycle packs, and as such are paced more similarly to an individual time-trial (Bernard et al. 2007). This could allow more intrinsic control over the pacing strategy adopted, hence a greater reflection of the individual responses to the physiological demands and psychological control involved during the race. The most striking result from our data is that the females adopted a more aggressive pacing strategy during the initial stages of the cycle discipline, compared with males. Indeed, a higher pacing index was elicited by females during the first split across all triathlon distances (Figure 1). This interesting observation diverges from past research examining draft-legal races (Le Meur et al. 2009), and is contrary to popular belief that males pace more aggressively at the beginning of triathlon races. A fast-start pacing strategy as elicited by females is thought to be sub-optimal, since the relatively high-intensity likely leads to an increase in oxygen consumption, greater accumulation of intramuscular metabolites and an increase in rating of perceived exertion early in the race (Thompson et al. 2003). Instead, it is considered optimal during prolonged events if athletes are able to balance propulsive and resistive forces in order to adopt a relatively even pacing strategy (Abbiss and Laursen 2008). Indeed, it has been shown that the top 10 runners of a 100 km running race adopted a relatively even pace, especially for the first 50 km (Lambert et al. 2004). Similarly, top athletes in an elite Olympic distance triathlon minimised decrements in running speed during the late stages of the 10 km run to maintain a more even pace, despite changes in elevation (Le Meur et al. 2011). As the participants within this study were the most successful athletes within the event (i.e. the top 20% age-group triathletes), it is possible that a relatively more aggressive start may be optimal for women, but a less aggressive start favourable for men.

In addition to a more even pacing strategy during the cycle discipline, males also adopted a more even pacing strategy during the start (split 1) of the sprint distance run (1.3% closer to mean). This less aggressive start may be partly responsible for the “end-spurt phenomenon,” characterised by speeding up towards the end of the race (Tucker et al. 2004), which was more apparent in males during the final split of the run (split 5, Figure 1). Indeed, a less apparent end-spurt was observed in females, who elicited a speed relatively closer to the mean during the final stages of the run (1.2% lower than males). The relatively faster start in females could have resulted in premature fatigue and impeded their ability to increase speed towards the end of the run and cycle disciplines. However, there is also evidence to suggest that the end-spurt phenomenon is indicative of a ‘sub-optimal’ pacing strategy, attributed to a conservation of reserve energy not efficiently distributed throughout the race (St Clair Gibson and Noakes 2004; Tucker 2009). The differences in pacing between sexes are possibly associated with a lower number of overall female competitors (24% of total participation) and therefore varied depth of field, thereby influencing motivation of the specific athletes examined (Lepers et al. 2013). As such, it is unclear whether these top male and female athletes adopted optimal pacing strategies. More research is required to better understand the optimal pacing strategies of males and female athletes and the factors that influence the selection of pace during triathlon.

During the sprint distance, older athletes were found to decrease speed to a greater extent during the final cycling section. Supporting this, an age-related difference was observed at split 5, where the pacing index of 50-59 y was 3.4% lower than the 20-29 y age-group. This decrease in speed may have been associated with a conscious decision by older athletes to reduce intensity in order to minimise fatigue accumulation prior to the subsequent run. Indeed, previous data has shown that decreasing power output during the last 5 min of a 30 min cycle improved subsequent running performance (Suriano et al. 2007). Interestingly however, an increase in pacing before the final decrement in cycling speed was observed in the 50-59 y age-group, where pacing index was 3.0% higher than the 20-29 y age-groups. The reason for this increase in speed is unclear, but may be to pre-compensate for time lost at split 5, when preparing for the subsequent run.

Despite relatively high winds during the cycle discipline of the half-Ironman and Ironman events (Table 1), 30-39 y athletes were able to maintain a relatively even pacing strategy, compared with other age-groups. For instance, the speed of the 30-39 y athletes remained closer to the mean during the tailwind section at split 3 (1.0% lower than 20-29 y) and the subsequent headwind section at split 4 (0.9% higher than 20-29 y) in the half-Ironman event. Maintaining such an even distribution of pace during periods of varying external resistance (i.e. riding into a headwind or uphill) has been shown to benefit performance.[25,26] Indeed, it has been demonstrated that increasing power output on uphill sections of a course and reducing power output on downhill sections in attempt to minimise variations in speed results in meaningful improvements in performance (Atkinson and Brunskill 2000). It is possible that such strategies may have been partially responsible for the lower cycling time in the 30-39 y athletes, compared with other age-groups. Unfortunately, it was not possible to measure power output or physiological characteristics of participants in the present study in order to further understand mechanisms responsible for differences in pacing between groups. It is plausible that unlike the 30-39 y athletes, older athletes in the present study were physically unable to increase power output during the headwind section of the half-Ironman and Ironman races, which therefore resulted in a more variable distribution of speed. Therefore, athletes need to consider the relationship between individual physiological characteristics and self-selected pacing strategies during triathlon competition, especially in events with varying external resistance.

Regardless of sexes, the 20-29 y age-group adopted the most aggressive running pacing strategy during the initial stages of the sprint, Olympic and half-Ironman distance. Certainly, a higher pacing index was observed in 20-29 y for split 1 during the sprint (3.0% higher than 50+ y), Olympic (3.2% higher than 40-49 y), and half-Ironman (2.1% higher than 30-39 y) distance. Although a positive pacing strategy has been shown to be detrimental to run performance in an Olympic distance triathlon due to the central down-regulation of pace (Hausswirth et al. 2010), a positive pacing strategy did not appear to negatively affect run performance in the 20-29 y age-group. Further studies are required to investigate the effect of run start pacing on subsequent run performance during various triathlon distances.

Conclusions

The present study was designed to determine the effect of biological sex and age on pacing during the cycle and run disciplines in the sprint, Olympic, half-Ironman and Ironman distance triathlons. Results show that dissimilar pacing strategies are adopted by athletes of different ages and sex during various triathlon distances. Specifically, female triathletes were more aggressive during the initial phases of the cycling discipline across all distances, and the younger athletes were more aggressive during the initial stages of the run discipline in the sprint, Olympic and half-Ironman distances. Further, 30-39 y male athletes elicited a relatively even cycling pacing strategy during longer distance triathlons, which likely results in lower times. These results could be useful to coaches and athletes, and should be considered when planning race/competition strategies.

Practical applications

Age, sex and/or fitness may influence self-selected and possibly individual optimal pacing strategies. Athletes of different age and sex may need to trial different pacing strategies to determine individual optimal pacing for various triathlon distances.

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Conflict of interest

No conflict of interest was declared for all authors.

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