Gender and Age Considerations in Triathlon

—Romuald Lepers, PhD

Both gender and age can affect performance in triathlon. During these last decades, female triathletes have reduced the gap in triathlon with their male counterparts, especially in long-distance triathlons such as Ironman distance. Female triathletes such as Chrissie Wellington have led triathlon performance to a higher level. In addition to the improvement in female triathlete performance, an increase in participation of masters triathletes (more than 40 years old) has been observed recently. Masters triathletes can still achieve extremely high levels of performance: Dave Scott finished second overall at the Hawaii Ironman Triathlon at 42 years old in 1996; more recently, in 2012, Natascha Badmann finished 6th at Hawaii at 46 years old. Moreover, some unique older triathletes (up to 80 years of age) have begun to push the limits of the interaction between aging and human endurance. In this context, we could wonder how training and outcome expectations for the standard triathlon distances should be modified to the unique needs required by gender and age.

Gender Differences in Triathlon Performance

The gender difference in endurance performance has received considerable attention in these last decades, but most studies have focused on running. Previous studies that have investigated the participation and performance trends of female endurance athletes in running reported an increase in female participation and an improvement in performance during the last three decades.[1]

Although some authors have suggested that the gap in gender difference in endurance performance could be closed, more recent studies could not confirm this assumption, showing that the gender difference in endurance performance is no longer diminishing.[2] For elite runners the gender difference in marathon running performance has remained about the same since the 1980s at a difference of approximately 10 percent.[3] Gender difference in triathlon regarding participation and performances has been less investigated.

Physiological Considerations

Physiological and morphological characteristics may be responsible for gender difference in triathlon performance. Little information was available on the physiological determinants of endurance performance in women until the 1970s. The current available data, while limited in comparison to those available on men, suggest that maximal oxygen uptake ($\dot{V}O_2max$), lactate threshold, and running economy interact in women as determinants of endurance performance in a manner similar to that in men.

The current explanation of gender differences in $\dot{V}O_2max$ among elite athletes when expressed relative to body mass is twofold:

- First, elite females have more body fat than males (about 13 percent versus about 5 percent). Much of the difference in $\dot{V}O_2max$ disappears when it is expressed relative to lean body mass.
- Second, the hemoglobin concentration of elite athletes is 5 to 10 percent lower in women than in men.

Concerning lactate threshold, there is no reason to believe that values will be lower in women than in men because mitochondrial adaptations in the skeletal muscles of highly trained male and female athletes appear similar. Finally, the average oxygen cost to run a given speed (i.e., running economy) by groups of elite male and female athletes appears to be similar and probably plays the same role in determining success in endurance performance. Therefore, the major physiological reason to explain the slower record performances by women than men is probably the lower $\dot{V}O_2max$ values observed in women. Although a number of elite male and female athletes have similar $\dot{V}O_2max$ values, these values are at the low end of the elite range for men versus the upper end of the elite range for women.

Male triathletes possess a larger muscle mass, correlating with greater muscular strength and lower relative body fat compared with females. Low body fat is an important predictor variable for total time performance in triathlon. For example, Knechtle, Knechtle, and Rosemann[4] showed that low body fat was associated with faster race times in male Ironman triathletes but not in females. Males retain on average 7 to 9 percent less percent body fat than females, which is likely an advantage for males. Therefore, gender differences in percentage body fat, oxygen carrying capacity, and muscle mass appear to be responsible for gender difference in triathlon performance. Note also that pregnancy and the menstruation cycle may affect training and racing.

Gender Difference in Participation and Performance Density

The number of females competing in triathlon has increased progressively since the 1980s. For example, the number of females finishing the Hawaii Ironman Triathlon increased from 20 in 1981 (6 percent of the participants), to more than 470 in 2010 (27 percent of the participants). By comparison, women represented 32 percent of the participants at the New York Marathon during the last 10 years. In Europe, a progressive rise in the number of female Ironman finishers also occurred, but the rate was lower. For example in 2010 females accounted for 8, 11, and 13 percent of the field at the France, Austria, and Switzerland Ironman triathlons, respectively. The lower rate of female participation in Europe is presumably explained by the fact that Ironman triathlon in Europe is younger compared with Hawaii Ironman Triathlon (first event held in 1978). Female participation in European Ironman triathlons will probably increase in the future.

For short-distance triathlon, the rate of female participation appears greater than for Ironman triathlon. For example, in 2010 at the Zurich (Switzerland) short-distance triathlon, females accounted for 26 percent of the field, but females made up only 13 percent for the Ironman distance held in the same city. Interestingly, the increase in female participation this last decade at the Zurich short-distance triathlon only appears for females between 40 and 54 years old and not for younger female triathletes. In contrast, the participation of male triathletes at this event did not change during the last decade.

Nowadays, female triathletes have the same opportunities to train and compete as males do. Females may be gaining more competitive opportunities as they age, or they may be seeking out competition later in life, after childbirth, or later in their careers. Another aspect linked to the increase in participation of female triathletes is motivation. If winning prize money can be an additional motivation for elite triathletes, having fun and staying in good health may be the main motivations for recreational female triathletes.

The performance density in triathlon, quantified by the time difference between the winner and 10th place, is greater in males than in females, whatever the event (see table 3.1). For example, at the Hawaii Ironman Triathlon between 1981 and 2010, the average time difference between the winner and 10th place was 5.8 percent for the males and 7.5 percent for the females. During the last 5 years, the time difference between the winner and 10th place decreased for both males (about 3.1 percent) and females (about 5.7 percent), suggesting that elite female performance density will probably become similar to what is seen among males in the future.

Table 3.1 Time Difference Between the Winner and 10th Place, Expressed as a Percentage of the Winner's Performance for Males and Females at Various Events in 2009

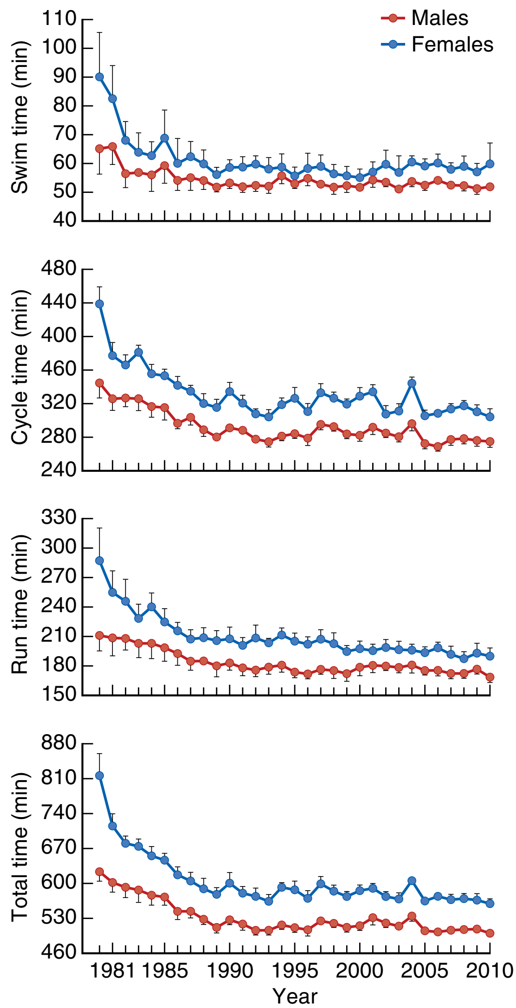
Difference 10th to 1st in 2009	Male	Female
Olympic Triathlon World Championship Grand final (with drafting) Gold Coast, Australia	0.7%	1.1%
Xterra Triathlon World Championship Maui, Hawaii, USA	4.5%	11.7%
Half-Ironman World Championship Clearwater, Florida, USA	3.5%	6.8%
ITU Long-Distance World Championship Perth, Australia	3.8%	9.8%
Ironman World Championship Kona, Hawaii, USA	2.3%	8.8%

Long-Distance Triathlon: The Example of the Hawaii Ironman Triathlon

The analysis of male and female performances during the Hawaii Ironman Triathlon World Championship, considered as the premier race in the field of long-distance triathlon, provides accurate insights into gender difference in long-distance triathlon. A study conducted by Lepers[5] in 2008 showed that overall performance time of elite male and female triathletes at the event decreased rapidly between 1981 and the late 1980s and then plateaued thereafter for both males and females (figure 3.1). During the last two decades, while swimming times for males and females and running times in males tended to stagnate, running times in females marginally improved. In contrast, cycling performance over time was more stochastic, presumably caused by the substantial effect of wind conditions. Between 1988 and 2010, the gender difference remained stable and practically identical for swimming (+0.8 percent per decade), increased a little for cycling (+1.3 percent per decade) and decreased somewhat more for running (–1.8 percent per decade).

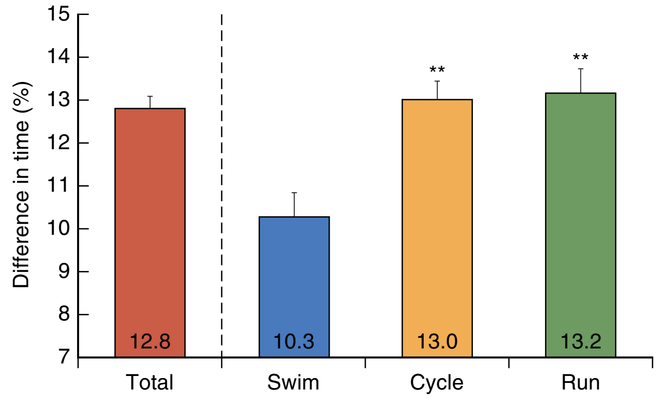
Gender Difference in Swimming is Smaller Than in Cycling or Running

The average gender difference in swimming performance at the Hawaii Ironman over the last 25 years was 10.3 percent (figure 3.2). The gender difference in Ironman 3.8-kilometer swimming is consistent with values found for various swimming events from 50- to 400-meter freestyle but is lower than the gender difference found for 100-meter freestyle. It has been suggested that swimming gender difference became progressively less with increasing distance between 50 and 1,500 meters.[6]



▶ **Figure 3.1** Swimming, cycling, running, and total performance times at the Hawaii Ironman Triathlon for the top 10 males and females from 1981 to 2010. Values are mean ± SD. Two races took place in 1982, in February and October.

Two factors could explain the reduced gender difference for longer distances, especially for ocean swimming compared with sprint events in the pool. First, the denser salt water compared with fresh water would likely raise more of a female's body out of the water because females have more body fat than males do. This positioning would reduce surface area in the water and total drag compared with swimming in fresh water and give some specific advantage to females. Second, according to swimming studies, at lower velocity a woman's drag coefficient drops somewhat compared with a man's in any similar water condition.



▶ **Figure 3.2** Average gender difference in time performance for total event, swimming, cycling, and running at the Hawaii Ironman Triathlon for the top 10 males and females from 1986 to 2010. Values are means ± SE. **Significantly different from swim, P < 0.01.

The swimming gender difference in time (10.3 percent) appears on average smaller compared with cycling (13.0 percent) and running (13.2 percent) (figure 3.2). The difference between swimming and the two other disciplines could be explained in part by the biological gender difference in relative body fat (body mass in females is 7 to 9 percent higher). Indeed, greater body fat may represent a limit in weight-bearing activities such as running, but in contrast it increases buoyancy in water.

Moreover, it has been shown that the underwater torque, a measure of the tendency of the feet to sink, is lower for females than for males. In addition, the mechanical efficiency of swimming corrected to body surface area is greater for females than for males. Upper-body strength differences between males and females are larger compared with differences in the lower body, so presumably buoyancy issues outweigh this difference. These factors could explain the reduced difference between males and females in swimming compared with running and cycling.

Cycling Gender Difference Comparisons Are Difficult

The average gender difference in cycling at the Hawaii Ironman is 13.0 percent in performance time. Cycling performance comparison between genders in single cycling events is difficult because cycling does not have an official time-trial championship with a distance close to 180 kilometers at the same distance for males and females. For example, at the 2007 world cycling time-trial championships, the difference between the male champion's pace and the female champion's pace was 11.5 percent, but males rode 44.9 kilometers and females rode 25.1 kilometers. Schumacher, Mueller, and Keul[7] reported that in track cycling the gender gap difference between males and females appeared constant (about 11 percent) for distances between 200 and 1,000 meters.

The available data suggest that the difference in cycling between males and females is of similar magnitude for much longer time-trial cycling. Greater muscle mass and aerobic capacity in males, even expressed relative to lean body mass, may represent an advantage during long-distance cycling, especially on a relatively flat course such as Ironman cycling, where cycling approximates a non-weight-bearing sport. Indeed, it has been shown that absolute power output, which among elites is greater for males than females, is associated with successful performance. In addition, a significant correlation has been reported between 40-kilometer time-trial performance and body mass.[8]

Running Gender Difference is Slightly Decreasing

Over the last 25 years, the top 10 males have run the Hawaii Ironman marathon on average 13.2 percent faster than the top 10 females. The physiological differences between males and females in running performance that are well identified in the literature persist in the marathon of an Ironman. Morphological (body fatness) and physiological gender differences, such as oxygen carrying capacity (hemoglobin concentration) may partly account for the gender difference in distance running performance.

Interestingly, during the last 25 years elite female triathletes improved their running time by 0.8 minutes per year while running time remained stable for males. The reasons for such an improvement in female running performance at Ironman distance is not clear because both males and females had the opportunity to use new training methods (e.g., altitude training) and advances in nutrition. If females continue to improve their running performance at Ironman in the future, they could reduce the gender difference in the marathon and therefore in overall performance. The best example is Chrissie Wellington, who astonishingly reduced the gap in running with her male counterpart in Roth Ironman (Germany) to the world's fastest Ironman distance performance for both males and females (see table 3.2).

Table 3.2 World Best Total Event Performance Times (h:min:s) for Males and Females With Corresponding Split Times Without Transition Times for Swimming, Cycling, and Running at the Hawaii Ironman Triathlon and Roth Ironman (Germany)

Gender difference is expressed as a percentage of the male's time.

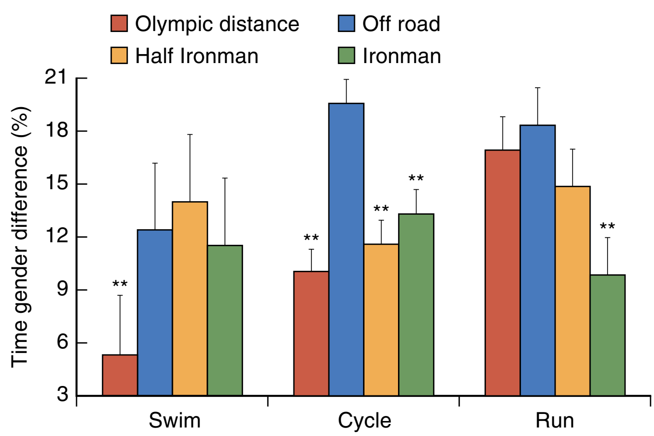
Ironman course records	Total	Swim 3.8 km	Cycle 180 km	Run 42 km
HAWAII IRONMAN TRIATHLON				
Male, Craig Alexander (2011)	8:03:56	51:56	4:24:05	2:44:02
Female, Chrissie Wellington (2009)	8:54:02	54:31	4:52:06	3:03:05
Gender difference	*10.3%*	*5.0%*	*10.6%*	*11.6%*
ROTH IRONMAN (GERMANY)				
Male, Andreas Raelert (2011)	7:41:33	46:18	4:11:43	2:40:52
Female, Chrissie Wellington (2011)	8:18:05	49:49	4:40:39	2:44:35
Gender difference	*7.9%*	*7.6%*	*11.5%*	*2.6%*

Observations on ultratriathlons such as double- or triple-Ironman-distance triathlon show greater gender difference in performance compared with Ironman distance.[9, 10] For example, the gender difference in total time performance for both double- and triple-Ironman distance triathlons is close to 19 percent, which is greater than that found for an Ironman (about 13 percent). But nonphysiological factors may have contributed to these observations. For example, the widening of gender difference with increased distance could be caused in part by the fewer number of female finishers in ultratriathlons.

Comparison Between Short and Long Distances

Surprisingly, gender differences in short-distance triathlon (consisting of a 1.5-kilometer swim, 40-kilometer bike, and 10-kilometer run) performances for elite athletes have been less investigated. One reason may be that the top international Olympic-distance triathlons (i.e., World Championship Series events) have all been draft legal for several years and therefore finding a reference of high-level Olympic-distance triathlon without drafting for comparison is difficult. The addition of several nondrafting international-distance triathlons that offer a competitive platform for professional triathletes should help in analyzing gender difference in short-distance triathlon performance in the future.

Gender differences in times for swimming, cycling, running, and total event have been compared for triathlons with distances from Olympic to Ironman distance for the top 10 elite males and females (figure 3.3). Gender difference in time for swimming was lower for Olympic distance triathlon (5.4



▶ **Figure 3.3** Mean percentage difference in time for swimming, cycling, and running at four triathlon events of different types (2007, 2008, and 2009; data pooled) between the top 10 females and males: Olympic distance, World Cup Triathlon (Des Moines, Iowa, USA); off-road, Xterra Triathlon World Championship (Makena, Hawaii, USA); half-ironman, Half-Ironman Triathlon World Championship (Clearwater, Florida, USA); Ironman, Ironman Triathlon World Championship (Kona, Hawaii, USA). Values are means ± SE. $^{**}P < 0.01$, significantly different from off-road triathlon.

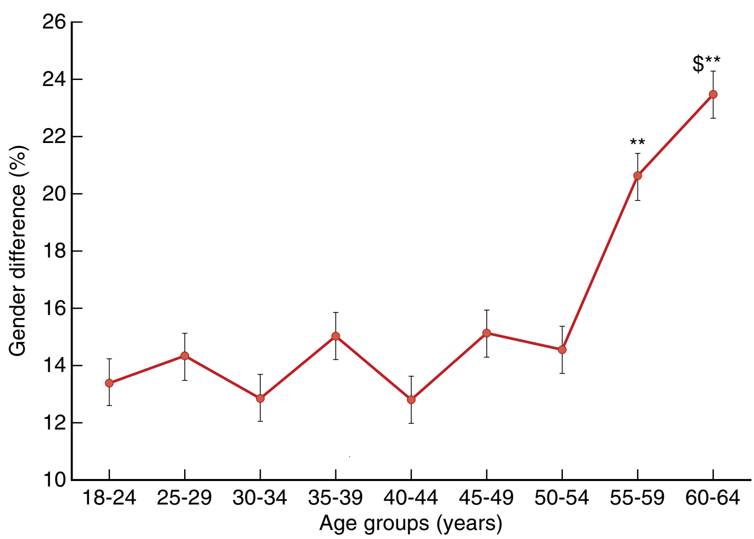
percent) than for other triathlons (about 10 to 13 percent). For cycling, gender difference did not differ between the three conventional distances (about 10 to 13 percent). Gender difference in time for running was lower for Ironman triathlon (9.7 percent) than for other triathlons (about 14 to 18 percent).

Gender and Age Interaction in Triathlon Performance

Knowing that the physiological (e.g., muscle strength, oxygen carrying capacity) and morphological (e.g., percentage of body fat, muscle mass) functional characteristics change with advancing age, gender difference in triathlon performance may also change with advancing age. After age 55, the decline in athletic performance increases exponentially in both sexes, but this decline is typically more pronounced in women than in men.[11] This change in gender difference with advancing age has been examined at the Hawaii Ironman Triathlon[12] (see figure 3.4).

Figure 3.4 shows that gender difference in total event performance time increased significantly with advancing age from 55 years. Male triathletes at the age of 60 years were on average 27 percent slower than the 30- to 40-year-old triathletes, and the difference reached 38 percent for women.

Age- and gender-related differences in swimming, cycling, and running performances likely result from physiological, sociological, and psychological changes that occur. The exact reasons for these sex-related differences



▶ **Figure 3.4** Average gender difference in time for total event at the Hawaii Ironman Triathlon (2006, 2007, 2008 pool data). Values are means ± 95 percent CI. **Significantly different from all age groups from 20 to 24 to 50 to 55 years, $P < 0.01$. $ Significantly different from age group 55 to 59 years, $P < 0.05$.

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are not clear. A greater decline of one or more physiological determinants of endurance performance for women compared with men (e.g., maximal oxygen uptake, lactate threshold, and exercise economy) has not been evidenced.

Age-related changes in body composition (i.e., increase in percentage body fat and loss of muscular mass), hormonal changes, and fluid balance changes (e.g., decline in the thirst mechanism) could also differ between males and females and affect triathlon performance. Finally, the reduction in training volume and intensity could contribute to the larger declines in endurance performance of elderly athletes. Differences in terms of years of training, training volume, and intensity between elderly men and women triathletes performing Ironman triathlon may exist, but further work is required to clarify this.

Interpretation of cross-sectional comparisons of triathlon performance times across ages and sexes must be made carefully. Compared with men, fewer women are competing in triathlon events, especially in the older age categories. For example, the percentage of women participating at the Hawaii Ironman Triathlon during 2007 to 2009 corresponded on average to 27 percent, but women finishers in the age group 60 to 64 years represented only 3 percent of the women's field. This participation difference will no doubt diminish over the next couple of decades. As a result, triathlon performances of the oldest women will probably improve more rapidly than those of the oldest men as the new generation of well-trained young female athletes moves into older age group competition.

Age-Related Decline in Triathlon Performance

Even if it is possible for an 80-year-old male athlete to finish an Ironman triathlon in less than 17 hours (e.g., Lew Hollander finished the Hawaii Ironman Triathlon in 15:48 in 2010; see table 3.3), the gradient in declining performances increased notably after the age of 55 years for both sexes, and female performances tended to decline faster than those of males. According to Reaburn and Dascombe,[13] the physiological factors affecting endurance performance with increasing age are maximum oxygen consumption ($\dot{V}O_2max$), maximal heart rate, stroke volume, lactate threshold, economy of movement, muscle-fiber type, activity of aerobic enzymes, blood volume, and skeletal muscle mass.

The decline in endurance performance appears primarily because of an age-related decrease in $\dot{V}O_2max$. The decrease of muscle mass with advancing age plays a role in the age-related decrease in $\dot{V}O_2max$ in master endurance athletes. On average, the muscle area decreases by about 40 percent between 20 and 80 years old. Both slow- and fast-twitch fibers decline with increasing age, although the loss of fast-twitch fibers is greater.

Table 3.3 Best Total Performance Times for Male and Female Age Groups With Corresponding Split Times at the Hawaii Ironman Triathlon

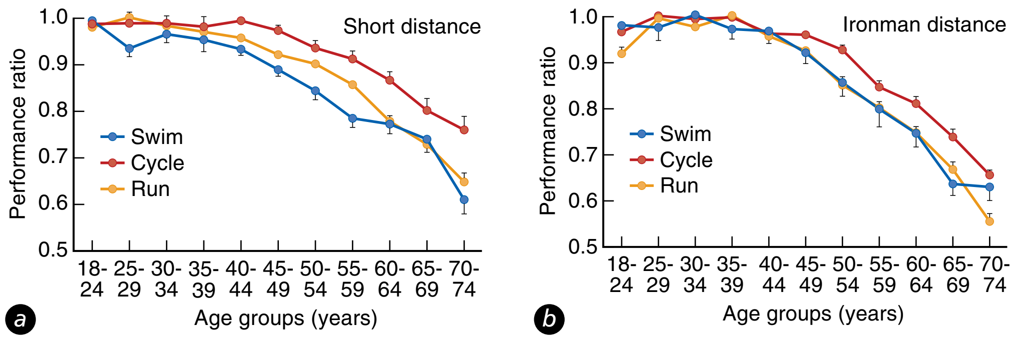
	MALE									
Year	**2011**[a]	**1996**[b]	**2009**	**2006**	**2005**	**2010**	**2011**	**2011**	**2005**	**2012**
Age group (years)	18–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	>80
3.8 km swim (h:min:s)	51:56	53:16	56:55	1:03:32	1:07:09	1:16:20	1:14:11	1:47:46	1:37:47	1:49:34
180 km cycle (h:min:s)	4:24:05	4:49:55	5:04:47	4:51:44	5:00:17	5:19:17	5:42:08	5:47:33	6:39:35	7:42:08
42 km run (h:min:s)	2:44:02	2:45:20	3:04:21	3:24:51	3:34:03	3:25:28	4:14:52	3:52:47	4:55:43	5:41:51
Total (h:min:s)	8:03:56	8:28:31	9:11:24	9:26:23	9:47:29	10:08:15	11:19:07	11:45:05	13:27:50	15:38:25
	FEMALE									
Year	**2009**[c]	**2010**	**2012**[d]	**2005**	**2010**	**2010**	**2010**	**2000**	**2005**	**NA**
Age group (years)	18–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	NA
3.8 km swim (h:min:s)	54:31	1:13:52	1:06:21	1:08:08	1:06:18	1:32:16	1:21:02	1:37:54	1:45:05	NA
180 km cycle (h:min:s)	4:52:06	5:25:00	5:06:07	5:31:56	5:35:36	6:27:46	6:47:28	7:24:33	7:25:17	NA
42 km run (h:min:s)	3:03:05	3:17:48	3:09:18	3:47:23	4:00:08	4:05:22	4:59:01	6:07:02	6:19:43	NA
Total (h:min:s)	8:54:02	10:02:35	9:26:25	10:35:59	10:51:43	12:17:24	13:16:32	15:19:19	15:54:16	NA

[a]Craig Alexander, 38 years old; [b]Dave Scott, 42 years old; [c]Chrissie Wellington, 32 years old; [d]Natascha Badmann, 45 years old.

Effect of Locomotion Mode

The age-related decline in triathlon performance is specific to the discipline. For both short- and long-distance triathlons, the age-related decline in cycling performance is less compared with running and swimming performances[14, 15, 16] (see figure 3.5). The question of whether there is better maintenance of cycling performance or a greater decline in running and swimming performances with advancing age can be raised.

One explanation for the different age-related declines in cycling and running may involve the mechanical power required by those disciplines. Mechanical power output (P) in running depends on the velocity (V) because $P = k \times V$ (k is a constant), whereas it depends on the third power of velocity in cycling ($P = k \times V^3$). If we assume that the changes in aerobic capacity (e.g., $\dot{V}O_2max$) with age are directly related to the decline in mechanical power, a similar reduction in power output for running and cycling with advancing age would induce a lower reduction in cycling velocity compared with running velocity. This relationship may explain, in part, why the magnitude of the decrease in cycling performance with age was less than that for running.



▸ **Figure 3.5** Age-related decline in swimming, cycling, and running performance for (*a*) short-distance triathlon and for (*b*) Ironman-distance triathlon (*b*) (mean ± SE). For short-distance triathlon the cycling performance ratio remained significantly ($P < 0.01$) greater than swimming from age group 40 onward, and from age group 45 the cycling performance ratio remained significantly ($P < 0.01$) greater than running. For Ironman-distance triathlon, the cycling performance ratio remained significantly ($P < 0.01$) greater than swimming from age group 45 onward, except for age group 70, and from age group 50 the cycling performance ratio remained significantly ($P < 0.01$) greater than running.

Adapted, by permission, from R. Lepers, F. Sultana, T. Bernard, et al., 2010, "Age-related changes in triathlon performance," *International Journal of Sports Medicine* 31(4): 251-256.

Running involves stretch-shortening cycles (SSC) with eccentric muscle contractions, whereas cycling is a non-weight-bearing activity that involves dominant concentric muscle contractions. Fast-twitch fibers, however, atrophy more than slow-twitch fibers do with age. Because fast-twitch fibers seem more susceptible to damage than slow-twitch fibers during SSC, the greater reduction in running performance compared with cycling could be related to muscle typology changes with age.

But the changes in muscle fiber type distribution (i.e., the percentage of type I muscle fibers) with advancing age seem less pronounced in well-trained masters athletes compared with untrained older adults. Moreover, in terms of muscle damage, although some animal studies have shown that recovery from eccentric exercise-induced muscle damage is lessened in older subjects compared with the young, the results from human studies are not as clear. Results might differ among muscle groups, but there is no evidence that the muscles of older triathletes are more susceptible to muscle damage than muscles of young triathletes.

Findings for competitive long-distance runners indicate that the decline in running times parallels the age-related reductions in maximal oxygen uptake and lactate threshold. The contributions of these respective physiological factors to age-related declines in cycling performance, however, are unknown at present.

Indeed, few studies are available on the effect of age on cycling performance. For example, Balmer, Bird, and Davison[17]characterized the decline in maximal oxygen consumption and maximal aerobic power with age in cycling. These authors found that the relative intensity expressed as a percentage of maximal heart rate or maximal oxygen uptake as well as economy was not affected by age during a 20-minute time trial. Thus, the possible lesser decline in cycling performance with advancing age, because of a lesser reduction in lactate threshold or economy compared with running, needs to be confirmed by additional studies.

An alternative explanation for the smaller age-related performance decline in cycling compared with running is the maintenance of a relatively greater exercise training stimulus in cycling. An overall reduction in the exercise training stimulus generally occurs with advancing age. In running, the decline in exercise performance with age has been partly attributed to an increased incidence of orthopedic injuries, which would limit running training volume of many older athletes. This factor may influence cycling performance to a much lesser extent.

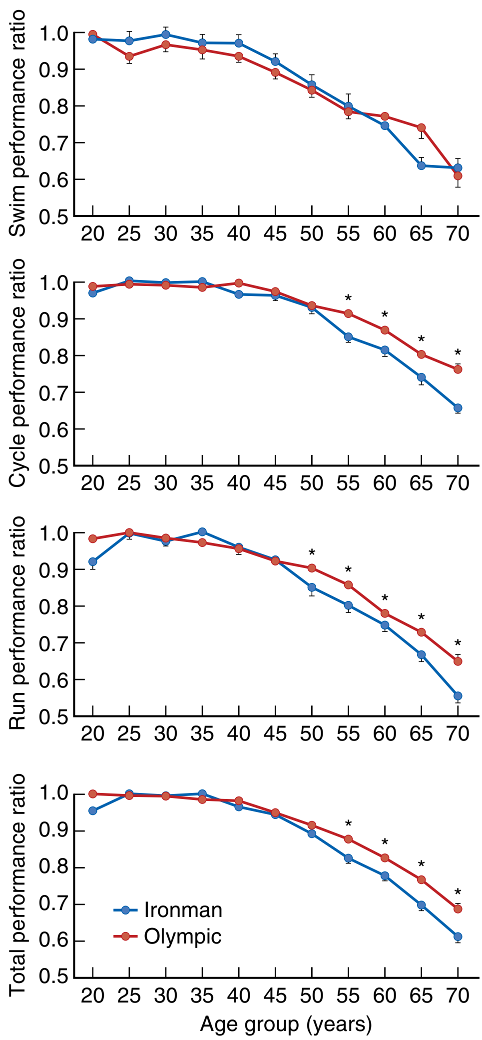
Moreover, it has been shown that the protein synthesis rate decreases in older subjects compared with young subjects, which could limit running training volume in older triathletes in which muscle damage occurs. With advancing age, triathletes would likely spend more training time cycling than running because of changes in physical factors (e.g., increased prevalence of injuries). Further prospective studies are necessary to quantify the changes in training volume in triathletes with age because training history is an important aspect of performance status at older age.

Comparison Between Short and Long Distances

The triathlon duration exerts an important influence on the age-associated changes in triathlon performance.[15] It has been shown that age-related changes in swimming performance were not influenced by triathlon duration; the magnitudes of decreases in swimming performance were similar for Olympic versus Ironman triathlon (see figure 3.6). Swimming is the first discipline during a triathlon, so triathletes perform it without suffering from accumulated fatigue, in contrast to the cycling and running disciplines. On average, swimming performance declines by about 15 percent at 50 years old and reaches about 38 percent by 70 years of age.

Previous studies showed no effect of task duration for shorter-distance swimming events. For example, Tanaka and Seals[6] found no significant differences in the magnitude of performance decline with age (about 32 percent at 70 years) among distance events ranging from 100 to 1500 meters in a pool. The lower performance decline observed by these authors for the same age (70 years old) compared with triathlon data might be related to differences between water conditions: calm in swimming pools versus stochastic in open water for triathlon.

In contrast to swimming, cycling and running with advancing age had a less pronounced decline at Olympic triathlon than at Ironman triathlon. It is not clear why task duration in triathlon exerts an influence on age-related declines in cycling and running performance.



▶ **Figure 3.6** Age-related decline in swimming, cycling, running, and total performance for short-distance and Ironman distance triathlons (mean ± SE). There was no distance effect for swimming performance, but age-related declines in cycling, running, and total performance were less pronounced for short-distance triathlon. *P < 0.01, significantly different from Ironman distance triathlon for the same age group.

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For the 70 to 74 year age group, the finish time is about 3 hours for the Olympic triathlon versus about 15 hours for Ironman triathlon. Certainly, the Ironman triathlon induces greater neuromuscular fatigue in cycling and running compared with Olympic triathlon. Furthermore, muscle damage during a 10K run of Olympic distance is limited compared with that occurring during the Ironman marathon. Endurance exercise increases the use of endogenous fuels to provide energy for working muscles.

It has been suggested that older subjects oxidize more glucose and less fat during moderate-intensity exercise.[18] Compared with young adults, older adults seem to oxidize less fat during endurance exercise performed at either the same absolute or relative intensity.[19] This shift in substrate use is presumably caused by age-related changes in skeletal muscle, including decreased skeletal muscle respiratory capacity. Therefore, changes in substrate availability and utilization with advancing age may explain in part the task duration effect on triathlon performances, at least in cycling and running.

Additional studies examining the changes in training volume and physiological characteristics of older triathletes are required to understand the age-associated changes in triathlon performance. Such studies will provide valuable information for understanding how to maintain physical capacity and performance with advancing age.

Conclusion

Physiological factors (e.g., percent body fat and oxygen carrying capacity) and nonphysiological factors (e.g., rate of participation) may be responsible for gender difference in triathlon performances. The difference in triathlon total performance between elite males and females (about 10 percent) is similar to differences seen in other endurance sports such as marathon running. Swimming gender difference in time is generally smaller compared with cycling and running and can be explained in part by the biological difference in relative body fat. Female triathletes now have the same opportunities as males do to train and compete, and an increase in female participation in the future will probably improve the female performance density that remains, to date, smaller than that in male races.

Age-related decline in triathlon performance depends on locomotion mode (swimming versus cycling versus running) and distance (short versus long distance). Although younger triathletes still have the advantage with regard to overall performance, masters triathletes have shown in these last decades a relative improvement of their performances in the three disciplines.[20]

The question as to whether older triathletes have reached their limits in triathlon performance should therefore be raised. Most health care providers agree that racing an Ironman triathlon after 50 years of age is not good for the body. But most older triathletes say that training for triathlon is one of the healthiest things that they can do. Where should the limits be set? If masters triathletes perform at a high level for a long time, it is reasonable to expect that those destined to maintain that intensity could do so because they remained largely injury free. A framework for preparticipation evaluation, training programs, and injury prevention is required to help older triathletes reach their participation and performance goals injury free, to maximize the benefits and minimize the risks.

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