Master triathletes have not reached limits in their Ironman triathlon performance

M. Stiefel¹, B. Knechtle¹,², R. Lepers³

¹Institute of General Practice and for Health Services Research, University of Zurich, Zurich, Switzerland, ²Gesundheitszentrum St. Gallen, St. Gallen, Switzerland, ³INSERM U1093, Faculty of Sport Sciences, University of Burgundy, Dijon, France

Corresponding author: Beat Knechtle, MD, Facharzt FMH für Allgemeinmedizin, Gesundheitszentrum St. Gallen, Vadianstrasse 26, 9001 St. Gallen, Switzerland. Tel: +41 0 71 226 82 82, Fax: +41 0 71 226 82 72, E-mail: beat.knechtle@hispeed.ch

Accepted for publication 2 April 2012

The purpose of this study was to analyze the participation and performance trends of male triathletes in the “Ironman Switzerland” from 1995 to 2010. Participation trends of all finishers aged between 18 and 64 years were analyzed over the 16-year period by considering four 4-year periods 1995–1998, 1999–2002, 2003–2006, and 2007–2010, respectively. The 3.8-km swimming, 180-km cycling, 42-km running times, and total race times were analyzed for the top 10 triathletes in each age group from 18 to 64 years. The participation of master triathletes (≥40 years old) increased over the years, representing on average 23%, 28%, 37%, and 48% of total male finishers during the four 4-year periods, respectively. Over the 1995–2010 period, triathletes older than 40 years significantly improved their performance in swimming, cycling, running, and in the total time taken to complete the race. The question whether master Ironman triathletes have yet reached limits in their performance during Ironman triathlon should be raised. Further studies investigating training regimes, competition experience, or sociodemographic factors are needed to gain better insights into the phenomenon of the relative improvement in ultra-endurance performance with advancing age.

Nowadays, in a society with an increasing part of older adults, successful ageing is of highest importance for the whole population (Lee & Tanaka, 1997; Wright & Perricelli, 2008). Regular physical activity is beneficial for overall health (Lee & Tanaka, 1997; Trappe, 2007; Ransdell et al., 2009), protects from diseases like diabetes or hypertension (Williams, 2009) and even very intense exercise increases longevity (Sanchis-Gomar et al., 2011). Athletes who maintain an active lifestyle age gracefully with few health problems, while those who lapse into inactivity regress toward general population norms for fitness, weight control, and health problems (Faulkner et al., 2008). Some studies even hypothesized that lifestyle factors have stronger influences on physiological capacity than age (Leyk et al., 2007, 2009). Therefore, master athletes, defined as athletes who exceeded the age requisite for success in elite competition, i.e., typically 35 to 40 years (Ransdell et al., 2009), represent an intriguing model for successful ageing (Tanaka & Seals, 2008; Wright & Perricelli, 2008; Arampatzis et al., 2011).

Health benefits and fitness are along with social factors, enjoyment, and competition reasons for masters’ participation in endurance events (Reaburn & Dascombe, 2008). Recent studies have accounted for the enormous increase in participation of master athletes (Ransdell et al., 2009). Master athletes’ participation rate increased in different running events; from marathon (Jokl et al., 2004; Lepers & Cattagni, 2011) to 100-km (Knechtle et al., 2011d) and 161-km ultra-marathons (Hoffman et al., 2010), while the participation rate of younger athletes decreased. It has been shown that master runners represented ~55% of the total field in marathon running (Leyk et al., 2009; Lepers & Cattagni, 2011), while their proportion reached ~70% in ultra-marathons (Hoffman et al., 2010; Knechtle et al., 2011d).

The age-related decline in performance in master athletes related to changes in physiological (e.g., oxygen carrying capacity, muscle strength) and morphological (e.g., muscle mass, percentage of body fat) functional characteristics, has been evidenced by numerous studies (Rogers et al., 1990; Pollock et al., 1997; Hawkins et al., 2001; Pimentel et al., 2003; Faulkner et al., 2008; Korhonen et al., 2009). In general, peak endurance performance is maintained until 35 years of age, followed by modest decreases until 50–60 years of age, and a progressively steeper decline thereafter (Tanaka & Seals, 2003, 2008; Trappe, 2007; Reaburn & Dascombe, 2008; Wright & Perricelli, 2008; Ransdell et al., 2009). The
rates of the decline in performance with age differ between the sports depending on the specific demands of the event (Tanaka & Seals, 2003; Wright & Perricelli, 2008). In marathon running (Jokl et al., 2004; Leyk et al., 2007; Lepers & Cattagni, 2011), as well as in long-distance triathlon (Lepers & Maffiuletti, 2011; Lepers et al., 2012), peak endurance performance level is usually attained at an age comprised between 20 and 40 years while for ultra-running the age of peak performance moves to older ages, i.e., 30–50 years (Hoffman, 2010; Knechtle et al., 2011d).

Despite the numerous studies on the age-related decline in endurance performance, there are few investigations on the performance trends over time of master athletes. Masters’ performance trends have been previously investigated at the “New York City Marathon” (Jokl et al., 2004; Lepers & Cattagni, 2011). These studies showed for example that over the 1983–1999 period, male runners older than 50 years of age improved their running performance (Jokl et al., 2004), while regarding the 1980–2009 period, only runners older than 65 years improved their performance. In contrast, performance times of younger marathoners at the “New York City Marathon” remained quite stable over the last three decades (Lepers & Cattagni, 2011).

Ironman triathlon involving successively 3.8-km swimming, 180-km cycling, and 42.2-km running is often considered as one of the world’s most challenging endurance events and represents an intriguing model of ultra-endurance performance (Lepers, 2008; Lepers et al., 2010; Knechtle et al., 2011a). Compared to marathon running, Ironman triathlon is relatively young in the field of endurance events where the first event was held in Hawaii in 1978 (Lepers, 2008). It has been previously shown that for elite triathletes, after an initial phase of rapid improvement of Ironman triathlon performance during the 1980s, there was a relative plateau, but at least in running and cycling, there were small improvements (Lepers, 2008). However, the performance and participation trends of master athletes in this multi-sport ultra-endurance event have not been previously investigated.

Therefore, the aim of the present study was to analyze the participation and performance trends of male Ironman triathletes, with a special emphasis on master triathletes (i.e., ≥40 years of age), at the “Ironman Switzerland” from 1995 to 2010. Respecting existing literature on running, we hypothesized both an increase in participation and an improvement in master triathletes’ performance over the 16-year studied period.

Material and methods

This study was approved by the institutional review board of St. Gallen, Switzerland, with waiver of the requirement for informed consent given that the study involved the analysis of publicly available data. The dataset from this study was obtained from the race website (http://www.ironman.ch) and from the race director. The age at the time of competition and swimming, cycling, running, and total time performances of the male finishers at the “Ironman Switzerland” were analyzed from 1995 to 2010. Females were not accounted in this study because their participation in that ultra-endurance event was low (~10% of the total field).

We focused on the “Ironman Switzerland” as a qualifying event for the Ironman Triathlon World Championship held every year in Kona, Hawaii (http://www.ironman.com). The “Ironman Switzerland” is with its 50–75 qualifying places for the “Ironman Hawaii” triathlon comparable to the other world’s greatest Ironman events. Between its inception in 1995 and 2010, a total of 15 939 male triathletes finished the “Ironman Switzerland”. The race is held each year in the city of Zurich during July. The race consists of a 3.8-km swim (two laps) in the lake of Zurich where wetsuits are allowed; a 180-km cycling course (two laps) with a total altitude difference of 1260 m; and a completely flat running course over the marathon distance (four laps).

Data analysis

Because there is a very small number of finisher triathletes older than 64 years, we considered only male triathletes aged from 18 to 64 years. The age groups distinguish the categories as follows: 18–24 years, 25–29 years, 30–34 years, 35–39 years, 40–44 years, 45–49 years, 50–54 years, 55–59 years, and 60–64 years, respectively. Since the number of finisher triathletes in the age group 60–64 years was frequently lower than 10, the age-related changes in performance were analyzed for age groups comprised between 18 and 59 years. Swimming, cycling, running, and total performance times were converted to minutes and averaged across the first 10 triathletes of each age group. In order to simplify the analysis over the 16 years studied period (1995–2010), we pooled data into four periods of 4 years: 1995–1998, 1999–2002, 2003–2006, and 2007–2010, respectively. Therefore, for each age group and each 4-year period, 40 time performances were considered.

Statistical analysis

Data are reported as means ± standard deviation (SD) in the text. One-way analysis of variance (ANOVA) was used to compare the mean swimming, cycling, running, and total times between the different age groups during the 1995–2010 period. A two-way ANOVA with between factors of age and 4-year group was used to compare percent of finishers per age groups, and swimming, cycling, running, and total times between the 4-year periods across the age groups. Performances of one subject could have been analyzed several times, inducing a data bias but because of the low probability that it happens, we still considered our groups as independent. Tukey’s post hoc analyses were used to test differences within the ANOVAs when appropriate. A significance level of P < 0.05 was used to identify statistical significance.

Results

Participation trends

The number of total male finishers increased across the four 4-year periods: 1995–1998: 1819 finishers; 1999–2002: 2992 finishers; 2003–2006: 4364 finishers; and 2007–2010: 6764 finishers, respectively. The mean age distribution of the male finishers over the 4-year periods is displayed in Fig. 1. The mean number of finishers older than 30 years of age increased during the four 4-year periods (Fig. 1a). During the last 4-year period, i.e., 2007–2010, the 5-year age brackets with the largest participation have been 35–39 years and 40–44 years.
with on average more than 400 finishers per year. Over the studied period, the percentage of finishers significantly decreased between 25 and 34 years, remained stable for age group 35–39 years since 1999–2002 and significantly increased between 40 and 49 years (Fig. 1b). Master triathletes (≥40 years old) represented on average 23%, 28%, 37%, and 48% of total male finishers during the 1995–1998, 1999–2002, 2003–2006, and 2007–2010 periods, respectively.

Age-related changes in performances

The relative contribution of each part of the overall Ironman triathlon performance remained constant across the ages. On average, the 3.8-km swimming, 180-km cycling, and 42-km running represented 10.7 ± 0.5%, 53.5 ± 1.3%, and 35.0 ± 0.8% of the total time, respectively. The mean age-related changes for swimming, cycling, running, and total performances throughout the 1995–2010 period are shown in Fig. 2. For the three disciplines and total race time, the performance times increased in a curvilinear manner with advancing age. There was a significant age effect for swimming ($F = 51.7; P < 0.001$), cycling ($F = 33.6; P < 0.001$), running ($F = 82.4; P < 0.001$), and total ($F = 64.8; P < 0.001$) times. Swimming, running, and total time performances were significantly lower in the age groups 40–44-year and older compared to younger age groups ranging from 18 to 39 years for swimming and from 25 to 39 years for running and total time. Cycling performances were significantly lower in the age groups 45–49 year and older compared to younger age groups.

Figure 3 shows the age-related changes in swimming, cycling, running, and total performances across the four 4-year periods. There was a significant age group × 4-year period interaction for swimming ($F = 6.2; P < 0.001$), cycling ($F = 11.2; P < 0.001$), running ($F = 9.5; P < 0.001$), and overall race time ($F = 22.3;
Fig. 2. Age-related changes in swimming, cycling, running, and total performances at “Ironman Switzerland” triathlon. Data were pooled from 1995 to 2010. Values are means ± SD. NS, nonsignificant difference between age groups.

Fig. 3. Age-related changes in swimming, cycling, running, and total performances across the four periods 1995–1998, 1999–2002, 2003–2006, and 2007–2010 at “Ironman Switzerland” triathlon. For clarity reasons, SDs were not shown. a, significantly different ($P < 0.01$) from 1995–1998 period. b, significantly different ($P < 0.01$) from 1999–2002 period. c, significantly different ($P < 0.01$) from 2003–2006 period.
Swimming performance times for age groups older than 45–49 years significantly decreased over the four periods. Cycling, running, and total performances times for age groups older than 40–44 years significantly decreased over the four periods. The changes in total time performances of the different age groups across the four periods are shown in Fig. 4. The performance improvement appeared much larger between the last two periods 2003–2006 and 2007–2010 than between any other period for the oldest age groups 50–54 and 55–59 years, respectively.

Discussion

The main findings of the present study were (a) an increase in participation of male master Ironman triathletes; they represented during the 2007–2010 period almost 50% of the total field; and (b) an improvement of master triathletes’ performances during the 16-year studied period, while performances of triathletes younger than 40 years old remained quite stable.

Changes in participation of master triathletes

It should be mentioned that the race organization of “Ironman Switzerland” has limited start places during the last years, and this entry cap has increased over the years reaching 2200 participants in 2010. However, this limitation would probably not change the relative proportion between the different age categories. Sociological and demographic changes may explain the increase in master athletes’ participation in Ironman triathlon. The development and encouragement of a health and sport policy was a common goal in the developed world during the past five decades (Lee & Tanaka, 1997). The healthier way of life resulted itself in a higher rate of active adults and is a main factor for the increased life expectancy as well (Savidan et al., 2010), what increases the probability of older competing in endurance events too (Lee & Tanaka, 1997; Ransdell et al., 2009). Figure 5 shows the relationship between the changes in percentage of the male “Ironman Switzerland” finishers and the changes in percentage of the Swiss general population per age group between the two periods 1995–1998 and 2007–2010, respectively. During the 16-year studied period, the percentage of age groups older than 40 years increased for both “Ironman Switzerland” finishers and Swiss population, while the percent of age groups comprised between 18 and 34 years remained stable or decreased. This finding suggests that the increase in older triathletes’ participation in “Ironman Switzerland” may be linked to the demographic changes in general population. Interestingly, the relative proportion of adults older than 40 years represented 52.5% of the Swiss population in 2010 (http://www.bfs.admin.ch), what is close to their recent relative Ironman participation rate. However, the proportion of older master athletes increased more than the proportion of those age groups in the general Swiss population, suggesting that older people have changed their awareness and lifestyle during these last two decades. Indeed, the better consideration by older people of the positive effects of physical activity upon health with advancing age, i.e., better

Fig. 4. Change in total time performances of the different age groups across the four periods 1995–1998, 1999–2002, 2003–2006, and 2007–2010 at “Ironman Switzerland” triathlon. For clarity reasons, SDs were not shown.
ageing, might be the primary reason for this high participation rate (Lee & Tanaka, 1997).

The high participation rate of male master Ironman triathletes may also be due to a great part of athletes who have started later in their life with triathlon. The Ironman triathlon is young in the field of ultra-endurance event with the first “Ironman Hawaii” triathlon in taking place in 1978 (Lepers, 2008). A study on “Ironman Lanzarote” in Spain found that Ironman competitors had on average 6 years of experience in triathlon, and they came from a variety of sporting backgrounds with most from running background, i.e., 28%, followed by swimming and cycling with 14% and 13%, respectively (Gulbin & Gaffney, 1999). The idea of short training histories is confirmed by an investigation on marathoners showing that the majority of master athletes have training histories of less than 7 years of running (Leyk et al., 2009). Master athletes were responsible for the considerable increase in total male finishers. We could expect that the participation rate of master triathletes will still increase in the future and will soon be greater than the participation rate of younger triathletes.

Age-related changes in performances

The highest Ironman triathlon performance level of triathletes aged between 25 and 39 years and the lesser age-related decline in cycling performance compared with running and swimming performances in triathlon are in accordance with previous studies (Bernard et al., 2010; Lepers et al., 2010, 2012; Lepers & Maffiuletti, 2011). Physiological (e.g., concentric muscle contractions) and mechanical (e.g., relation between mechanical power output and velocity, non-weight-bearing aspect) specificities of cycling compared with the two other disciplines may explain the lower age-related decline in cycling performance (Bernard et al., 2010; Lepers et al., 2010). Reductions in maximal oxygen uptake (VO2max) are along with the decrease in lactate threshold, the loss of muscle mass, and the increase in percent body fat primary reasons for the decline in functional endurance with age (Pollock et al., 1997; Hawkins et al., 2001; Reaburn & Dascombe, 2008; Tanaka & Seals, 2008; Korhonen et al., 2009; Ransdell et al., 2009). The potential slowing of some of the ageing processes through athletic training is known since the 1960s (Jokl et al., 2004). Physiological characteristics such as aerobic capacity (e.g., VO2max) and muscle strength decline at a similar rate with increasing age in master athletes and healthy controls (Rogers et al., 1990; Pollock et al., 1997; Pearson et al., 2002; Michaelis et al., 2008). However, the higher baseline levels in trained athletes represent an apparent age advantage of several years compared with age-matched sedentary adults (Pearson et al., 2002; Pimentel et al., 2003; Tanaka & Seals, 2003, 2008; Michaelis et al., 2008). Endurance-trained adults have impressive higher levels of VO2max compared to their sedentary counterparts, i.e., −50 mL/kg/min vs −33 mL/kg/min at the age of −60 years (Rogers et al., 1990; Pollock et al., 1997; Hawkins et al., 2001; Pimentel et al., 2003). The number of muscle fibers and motor units decreases after the age of 50 years, with a greater loss from the fast-contracting type II muscle fibers (Faulkner et al., 2008; Korhonen et al., 2009). Lifelong
physical activity does not appear to have an impact on the loss in fiber number, but the loss of fibers can be buffered to some degree by hypertrophy of fibers that remain. Especially, older athletes who do weight training seem to better maintain their muscle mass (Pollock et al., 1997). Body fat is ~10% higher in sedentary compared to endurance trained adults and it increases over lifespan, in trained from ~10% to ~20%, while in untrained from ~20% to ~30% (Pollock et al., 1997; Pimentel et al., 2003).

Changes in performance of master triathletes

According to our hypothesis, the master triathletes improved their performance across the 16-year study period. The economic development, with major technological, nutritional, and medical advances, offered a constant elevation of life resources in developed countries (Berthelot et al., 2008). This implied for athletes an improvement of training facilities, coaching, training techniques, nutritional strategies, and equipment. Because of sociological changes, older athletes attained more and more access to these improved training possibilities (Ransdell et al., 2009). Recent master athletes are likely to have had a longer and better access to these improved training possibilities than master athletes in earlier years. Wright and Perricelli (2008) found in a demographic survey of ~2600 participants in the “National Senior Olympic Games,” that most of the participants were middle class and well educated. Approximately 80% had graduated from college studies and 32% held postgraduate degrees. They concluded that the Senior Olympic Games participants may reflect the health benefits of their socioeconomic status. Performance improvements also happened because of the considerable increase of master Ironman triathletes’ participation. It is obvious that the higher participation rate increases the possibility of having better athletes. More successful athletes retain a higher intrinsic motivation to train and are more likely to compete in endurance events (Medic et al., 2007). Accordingly, the better condition of older athletes is likely to increase the competitive spirit, the participation, and the performance (Medic et al., 2007; Ransdell et al., 2009).

The advancement of training quality is in all probability a reason for these performance trends. The performance improvements of master triathletes in such an ultra-endurance discipline are amazing. Earlier investigations suggested that the performance decline with advancing age was because of decreased training volumes and intensity. The reduced training was a result of sociological factors like increased work and family commitments, behavioral factors such as a less intrinsic drive to train hard, and physiological factors like a longer time needed to recover and a higher risk for injuries (Reaburn & Dascombe, 2008; Tanaka & Seals, 2008; Korhonen et al., 2009; Ransdell et al., 2009). Training for an Ironman triathlon is very demanding (O’Toole, 1989; Gulbin & Gaffney, 1999; Knechtle et al., 2011c). It has been shown that recreational “Ironman Switzerland” participants spend every week almost 14 h training; e.g., 2.4 h for swimming, 6.7 h for cycling, and 4.7 h for running (Knechtle et al., 2011c). For comparison, half marathoners spend 4 h (Knechtle et al., 2010) and 100-km ultra-runners spend 7 h per week running (Knechtle et al., 2011b). It is obvious that to place in the top 10 of an age group category, both a large training volume and a high training intensity are required (Gulbin & Gaffney, 1999; Knechtle et al., 2011b, 2011c). However, it has been suggested that master athletes could optimize their quality of training, so they could reduce their training volume to save time for adequate recovery and stay free of injuries (Ransdell et al., 2009).

It has been shown that sport disciplines presented their highest progression curvature during their early phase (Desgorces et al., 2008). Although Ironman triathlon is a young ultra-endurance event, elite Ironman triathletes seem to have reached their performance limits (Desgorces et al., 2008; Lepers, 2008) as it is observed in more traditional sports like marathon (Jokl et al., 2004; Lepers & Cattagni, 2011). This rapid evolution of performance in Ironman triathlon may be based on the rapidly growing popularity of the event and benefits from the advances previously made in the three sports involved in triathlon (Desgorces et al., 2008). In addition, the fact that some elite swimmers, cyclists, and runners may start Ironman triathlon competitions later in their life, has and could help to increase the level of performance in master athletes. Unfortunately, we have no information about the sportive background of these successful master triathletes. Even if recreational master athletes had relatively short training histories and little experience in triathlon (Gulbin & Gaffney, 1999; Leyk et al., 2009), these successful athletes probably have lifelong histories of physical activity (Wright & Perricelli, 2008).

Methodological considerations

We are aware of some unavoidable limitations of our study. First, females were not accounted because of their lower participation rate. Previous studies on the age-related decline in performance concluded a greater decline in females than in males, but it was confounded by the relative smaller number of female vs males especially in the older age groups (Tanaka & Seals, 2003, 2008; Ransdell et al., 2009; Lepers & Maffiuletti, 2011). Second, there was no information about the individual factors, like physiological (e.g., aerobic capacity) and anthropometric (e.g., body weight, lean body mass) parameters, training regimes, and competition experience. Third, the influence of environmental conditions such as weather conditions and changes in sport equipment was unknown. Fourth, estimating the change in
percent of dropout in the different age groups across the years would have been interesting but unfortunately in the present study, we did not have the exact number of starters. Despite these limitations, the great number of male triathletes considered in the present study may give new insight on the age-related decline in ultra-endurance performance.

Perspectives

The participation of male master Ironman triathletes in “Ironman Switzerland” increased over the 1995–2010 period, and it will probably still grow in future. The improvement of master triathletes’ performance suggests that these athletes may not reach their limits in Ironman triathlon performance. It would be interesting to analyze the changes in age-related decline in performance at the World Ironman triathlon championship taking place each year in Hawaii during the last three decades and to compare with the present results observed on a qualifying event. Further studies investigating training regimes, competition experience, or socio-demographic factors are needed to gain better insights into the phenomenon of the relative improvement in ultra-endurance performance with advancing age.

Key words: ageing, age-related decline, sport, endurance performance.

Acknowledgements

We thank Mark Kleanthous, London, England, for his help in translation.

References


Master triathletes improved their performance


