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# Improved Race Times in Marathoners Older than 75 Years in the Last 25 Years in the World's Largest Marathons

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## Abstract

**Performance trends of elite marathoners are well investigated. However, performance of elderly marathoners (> 75 years) competing in the world's largest city marathons is not well-known. We examined marathon race data of 1,691 marathon finishes (*i.e.* 218 women and 1,473 men) competing between 1990 and 2014 in 5-year age groups 75-79, 80-84, 85-89, and 95-99 years in four races (Berlin, New York, Chicago and Boston) of the 'World Marathon Majors'. The number of female ($r^2$ = 0.50, $P$ < 0.0001) and male ($r^2$ = 0.88, $P$ < 0.0001) finishers increased significantly across years. The number of women ($r^2$ = 0.36, $P$ = 0.0019) and men ($r^2$ = 0.88, $P$ < 0.0001) in age group 75-79 years increased. In age group 80-84 years, the number of women ($r^2$ = 0.36, $P$ = 0.0111) and men ($r^2$ = 0.54, $P$ < 0.0001) also increased. In age groups 85-89 to 95-99 years, however, the number of female and male finishers remained unchanged. Across years, women ($r^2$ = 0.26, $P$ = 0.0090) and men ($r^2$ = 0.31, $P$ = 0.0035) reduced their race times. Women and men in age group 75-79 years improved race times. In age groups 80-84 to 90-94 years, women and men were not able to reduce race times. In summary, participation increased and performance improved in female and male marathoners competing in age groups 75-79 to 95-99 years where the largest increases in participation and the largest improvements in performance were found in women and men in age group 75-79 years.**

**Key Words: age group, master athlete, running, sex**

## Introduction

It is more than 100 years ago since the first modern marathon run with the official distance of 42.195 km took place during the 1908 Olympic Games in London (32). Johnny Hayes won the race in a time of 2:55:18 h:min:sec (25). The current world record for men is held by Dennis Kimetto (2:02:57 h:min:sec) set in Berlin in 2014 whereas for women it is 2:15:25 h:min:sec held since 2003 by Paula Radcliffe[1]. The winning time of Hayes in 1908 has been surpassed in 2004 by Ed Whitlock (age group M70) in Toronto[2].

Considering the large reduction of marathon race time of more than 50 min in nearly a century, it is tempting to speculate that the absolute limiting marathon times possible for a human being are not yet reached and might still decrease. Finishing a marathon in less than 2 h is expected in 2021 (11). Several models accounting for mathematical as well as physiological properties predict even faster race times like 1:48:25 h:min:sec (24) and 1:36:11 h:min:sec (26) as a potential world record time for men. For women, the predictions are less precise because of the lack of data due to the late onset of women's participation in Olympic marathon races in 1984. Nevertheless, Péronnet and Thibault (24) estimated the world record of the women's marathon to be set at 2:11:41 h:min:sec by 2033 while ultimate marathon limiting

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[1]IAAF world records by category, website www.iaaf.org/records/by-category/world-records, accessed May 22, 2015.
[2]World Masters Athletics, records outdoor men, website www.world-masters-athletics.org/records/outdoor-men, accessed May 22, 2015.
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times for women would be 2:00:33 h:min:sec.

Since the 1976 'New York City Marathon' so called 'urban tour' marathons took place (2), marathon races are no longer restricted to athletes competing in the Olympic Games. Moreover, these races are open to any motivated person who is willing to overcome the 42.195 km distance. Consequently, an increasing number of recreational runners are attracted by public marathon races.

In the case of the 'New York City Marathon', the numbers of male and female finishers increased between the decades 1980-1989 and 2000-2009 from 170,523 to 350,919 (17). Interestingly, since 1976, a dramatic increase of people older than 40 years participating in the marathon races was observed (2). Even runners in their 70's accounted for ~0.6% (n = 593) of the 'New York City Marathon' finishers during the decade 2000-2009 (17). Because it is known that the optimal age for accomplishing marathon records is ~31-32 years (1, 6), it is expected that the absolute world record marathon limiting times mentioned above will be most likely achieved by athletes of this age group. However, the emerging field of age group athletes showing significant improvements of running times (17) opens the question of age-related absolute limiting marathon times.

Until now, only a few studies have investigated performance trends of age group athletes in marathon running (1,11, 17, 18). These studies identified mainly that in the last ~30 years runners improved participation and running times in marathon races aside from certain age-group differences related to both age group and sex. One of the most recent studies clearly indicated significant running time improvements over time in particular in male runners older than 64 years and female runners older than 44 years (17). Although these results might be biased because the studies of Lepers and Cattagni (17) as well as Jokl *et al.* (11) analysed only the data of the 'New York City Marathon', it might be suggested that both male and female age group runners have not yet reached their absolute limits in marathon running. Therefore, future studies should overcome potential selection biases and incorporate data across multiple marathon races.

There are impressive individual record times for the marathon distance of 42.195 km for men in age group M75 (3:04:54 h:min:sec, Ed Whitlock), age group M80 (3:15:54 h:min:sec, Ed Whitlock), age group M85 (4:34:55 h:min:sec, Robert Horman), and age group M90 (6:46:34 h:min:sec, Ernest Van Leeuwen). For women, the records were 3:53:42 h:min:sec in age group W75 (Yoko Nakano), 4:12:44 h:min:sec in age group W80 (Gwen McFarlan), 5:14:26 h:min:sec in age group W85 (Betty Jean McHugh) and 8:53:08 h:min:sec in age group W90 (Mavis Lindgren)[3]. Furthermore, a 90-year old male athlete with a valid birth certificate finished a marathon race very recently in 6:48:55 h:min:sec (23). Clearly, some outstanding athletes like the above mentioned runners do not represent the mass of age group runners. However, there is a trend of improving performance and new world records in the age classes were set by aged athletes (15). It is reasonable to assume that an increased number of age group runners will reach and even outperform the actual age group record times in the future. There are two questions of particular interest when examining for absolute marathon limiting times in aged runners. First, what are the expected age-dependent individual limiting marathon times? Second, which mean limiting marathon times in certain age groups are feasible? Whereas the first aspect is rather a matter of interest for sports scientists or single athletes when assessing individual development potentialities and maximal physical capacity. Particularly, the latter is of some social importance considering aged athletes as a model for successful aging (5). Research on physiological changes during aging can be advanced with the investigation of aging athletes because of their obvious slowed age-related degenerative processes. Improved running times can be correlated to avoiding potential negative lifestyle parameters such as smoking and obesity. The cross-sectional assessment of aging athletes can be a tool for studying the 'real' age-related declines in humans apart from 'artificial' declines due to a modern sedentary lifestyle (19). Recent studies investigating performances of age group marathoners (11, 17, 18) have failed to include elderly runners such as the geriatric athletes (8) older than 75 years. We tested the hypothesis of an increased participation and an improved performance in elderly marathoners (> 75 years) in the last ~25 years by investigating marathon race times achieved in four of the largest city marathons as part of the 'World Marathon Majors' held between 1990 and 2014.

## Materials and Methods

*Data Sampling and Data Analysis*

This study was approved by the Institutional Review Board of St. Gallen, Switzerland, with a waiver of the requirement for informed consent given that the study involved the analysis of publicly available data. We collected marathon race times of female and male finishers in four of the world's largest city marathons: the 'BMW Berlin Marathon', the 'ING New York City Marathon', the 'BOA Chicago Marathon' and the 'Boston Marathon'. These races are part of the 'World

[3]World Masters Athletics, records, website www.world-masters-athletics.org/records, accessed May 22, 2015.

Marathon Majors' with six races held in Tokyo, Boston, London, Berlin, Chicago, and New York.[4] For the present study investigating age group athletes older than 75 years, we were not able to include the marathons in London and Tokyo since age group runners in London are only recorded as runners older than 70 years with no further separation in older age groups[5] and no age groups are recorded in the Tokyo Marathon[6]. Race results were obtained from the race websites 'BMW Berlin Marathon'[7], 'ING New York City Marathon'[8], 'BOA Chicago Marathon'[9] and 'Boston Marathon'[10]. We started data search in the end of 2014 and went back until no more finisher older than 75 years in 5-year age groups was found. The time frames were different for these races with 1999-2014 for the 'BMW Berlin Marathon'[7], 1990-2011 and 2013-2014 for the 'ING New York City Marathon'[8], 2004-2014 for the'BOA Chicago Marathon'[9] and 1996-2014 for the 'Boston Marathon'[10]. From 1990 to 2014, marathon race times of a total of 1,691 marathon finishes (*i.e.* 218 women and 1,473 men) of athletes aged 75-97 years were collected.

*Statistical Analysis*

Regression analysis was used to investigate a potential trend in participation. Gender difference was calculated using the equation ([race time in women] – [race time in men] / [race time in men] × 100). A mixed-effects regression model with finisher as random variable to include finishers who completed several races was used to calculate changes in performance of finishers. We included sex, age, squared age (because performance increases at decreasing rate with age) and calendar year as fixed variables. We also considered interaction effects between sex and age. The final model was selected by means of Akaike information Criterion (AIC). Statistical analyses were performed using IBM SPSS Statistics (Version 22, IBM SPSS, Chicago, IL, USA) and GraphPad Prism (Version 6.01, GraphPad Software, La Jolla, CA, USA). Significance was accepted $P < 0.05$. Data in the text and figures are given as mean ± standard deviation (SD).

## Results

*Participation Trends*

The number of female ($r^2 = 0.50$, $P < 0.0001$) and male ($r^2 = 0.88$, $P < 0.0001$) finishers increased significantly across years (Fig. 1). Most of the finishers competed in the 'ING New York City Marathon' (Fig. 2). For age groups, the number of women ($r^2 = 0.36$, $P = 0.0019$) and men ($r^2 = 0.88$, $P < 0.0001$) in age group 75-79 years increased (Fig. 3). In age group 80-84 years, the number of women ($r^2 = 0.36$, $P = 0.0111$) and men ($r^2 = 0.54$, $P < 0.0001$) also increased. In age group 85-89 years, however, the number of female ($r^2 = 0.03$, $P > 0.05$) and male ($r^2 = 0.00$, $P > 0.05$) finishers remained unchanged. Also for age groups 90-94 and 95-99 years, the number of female and male finishers showed no changes.

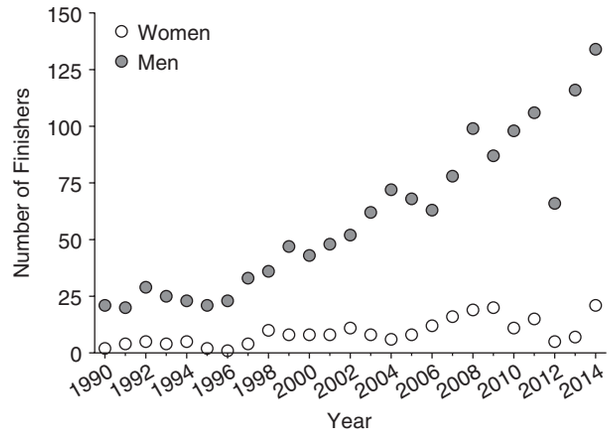


Fig. 1. Participation of female and male finishers from 1990 to 2014.

*Performance Trends*

Across years, women ($r^2 = 0.26$, $P = 0.0090$) and men ($r^2 = 0.31$, $P = 0.0035$) reduced their race times (Fig. 4). For age groups, women and men in age group 75-79 years reduced their race times (Fig. 5, Table 1). In age groups 80-84 to 90-94 years, both women and men were not able to improve their performance. Sex and age showed no interactions. Sex difference remained unchanged in age groups 75-79 ($r^2 = 0.01$, $P = 0.6305$) and 80-84 ($r^2 = 0.11$, $P = 0.1839$) years.

## Discussion

The present study investigated participation and performance trends in geriatric marathoners older than

[4]World Marathon Majors, website www.worldmarathonmajors.com, accessed May 22, 2015.
[5]Virgin Money London Marathon, website www.virginmoneylondonmarathon.com/en-gb, accessed May 22, 2015.
[6]Tokyo Marathon, website www.tokyo42195.org, accessed May 22, 2015.
[7]BMW Berlin Marathon, website www.bmw-berlin-marathon.com, accessed May 22, 2015.
[8]ING New York City Marathon, website www.tcsnycmarathon.org, accessed May 22, 2015.
[9]BOA Chicago Marathon, website www.chicagomarathon.com, accessed May 22, 2015.
[10]Boston Marathon, website www.baa.org, accessed May 22, 2015.

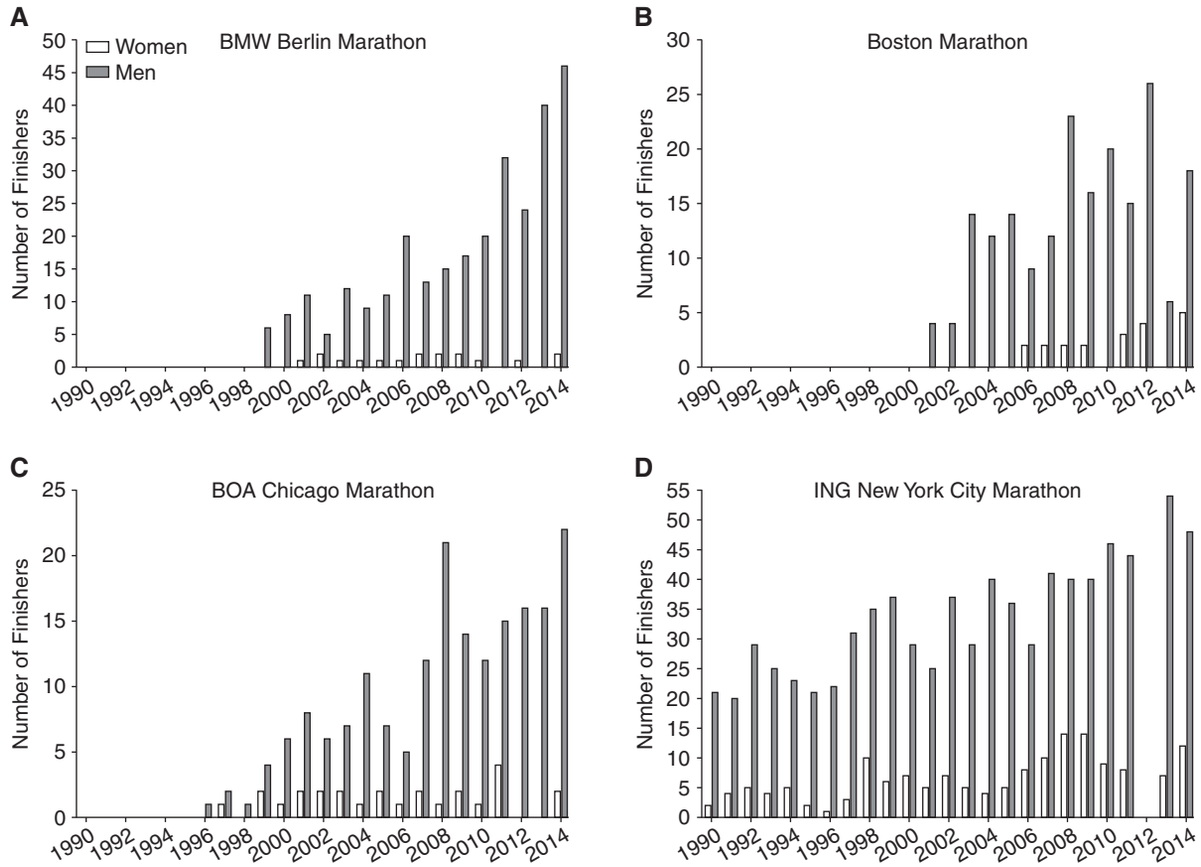


Fig. 2. Number of female (light grey bars) and male (dark grey bars) finishers for Berlin (Panel A), Boston (Panel B), Chicago (Panel C) and New York City (Panel D) Marathon.

75 years competing between 1990 and 2014 in four of the world's largest city marathons. Up to now, the focus of research of performance and participation in marathon and ultra-marathon races was mainly on age group runners younger than 79 years (10, 11, 14, 17, 27). In order to elucidate performance trends of athletes in the oldest age groups we conducted a study which is, to our best knowledge, the first one to assess geriatric athletes ranging from 75 to 97 years. The most important findings were that the number of female and male finishers increased and these finishers were able to reduce their race times. However, these changes were mainly limited to athletes in age groups 75-79 and 80-84 years.

*Participation Trends*

A first important finding was that the number of female and male finishers in age groups 75-79 and 80-84 years increased. This trend of increasing partakers for marathoners older than 75 years seems to represent the general trend in participation for age group marathoners competing in large city marathons. For example, Lepers and Cattagni (17) investigated the changes in participation and performance trends of master marathoners competing between 1980 and 2009 in the 'New York City Marathon'. They reported that the number of total finishers increased by 65% between decade 1980-1989 and 1990-1999 and by only 25% between decade 1990-1999 and 2000-2009. Therefore, our findings seem to be in line with the general trend in participation in master marathoners in the last ~30 years. The trend in participation might be influenced by the selection of the four races. Unfortunately, we were not able to consider all race races of the 'World Marathon Majors' but could only include data from Boston, Berlin, Chicago, and New York marathons and were not able to receive data from the races held in London and Tokyo. It would be very interesting to know the age of female and male Japanese marathoners since a quarter of all Japanese were older than 65 years in 2013[11]. Also athletic performance in elderly Japanese athletes appears to be outstanding. For example, in 2013, the 103-year-old runner

[11]Number of elderly in Japan hits record high, website www.japantimes.co.jp/news/2013/09/16/national/number-of-elderly-in-japan-hits-record-high/#.VV7D3FLLI6V, accessed May 22, 2015.

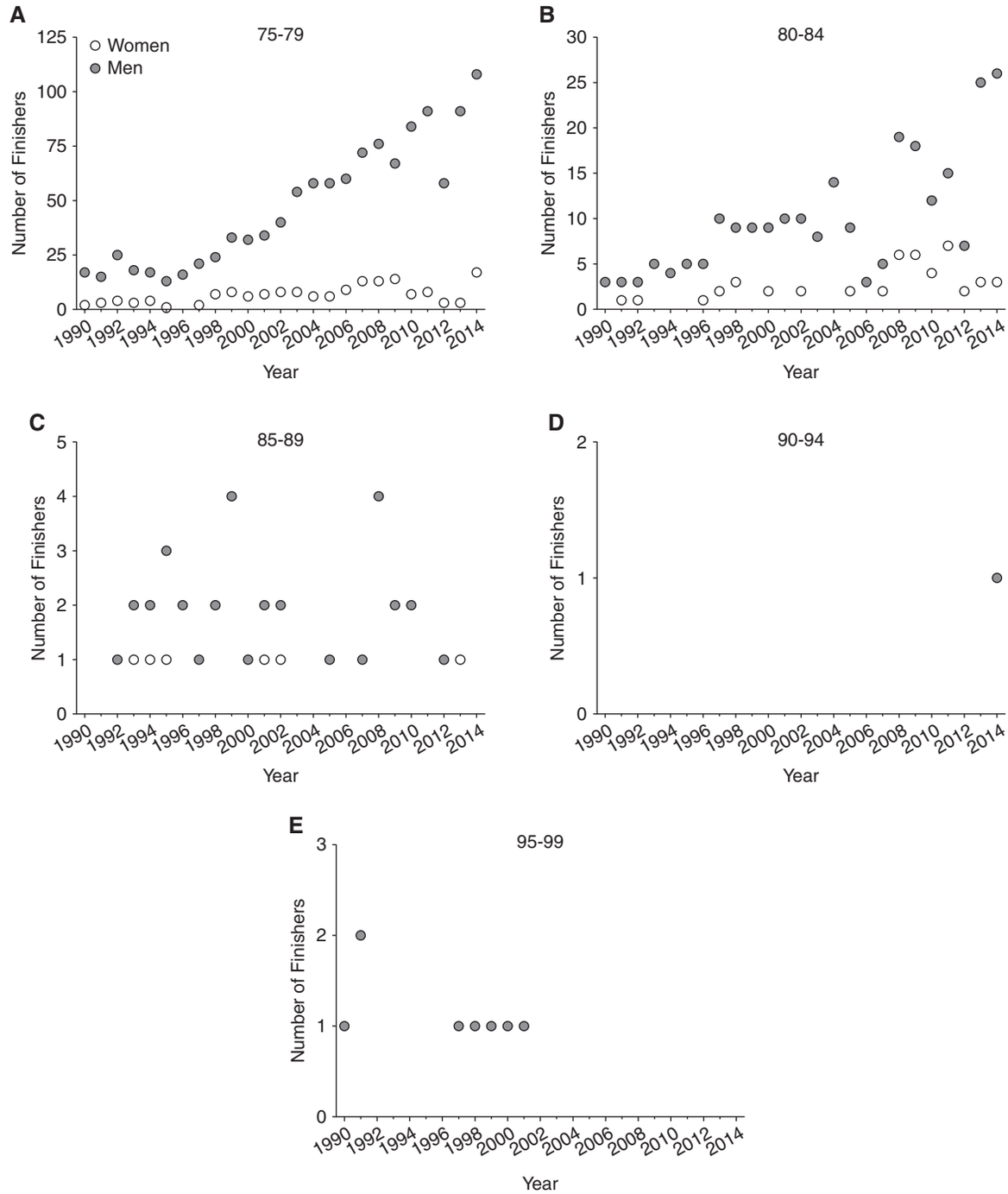


Fig. 3. Participation of female and male finishers in age groups 75-79 years (Panel A), 80-84 years (Panel B), 85-89 years (Panel C), 90-94 years (Panel D) and 95-99 years (Panel E).

Miyazaki Hidekichi achieved a final race time of 34.10 sec in 100 m track running during the 'International Gold Masters'[12]. Future studies might investigate athletic performance of other marathon races held in Japan. However, also elderly American marathoners are able for outstanding performances. Harriette Thompson finished at the age of 92 years and 65 days the 2015 edition of the 'San Diego's Rock 'n' Roll Marathon' within 7:24:36 h:min:sec[13].

The general trend of an increase of participants

[12]Aged Athletics: Seniors Show a Surprising Turn of Speed, website www.nippon.com/en/currents/d00103/, accessed May 22, 2015.
[13]92-year-old becomes oldest woman to complete marathon, website http://edition.cnn.com/2015/06/01/us/san-diego-marathon-oldest-woman-finishes/, accessed July 10, 2015.

**Table 1. Results of the mixed-effects regression analyses (cage = centered age)**

| Parameter | Estimate | Standard Error | df | *t* | Sig. |
|---|---|---|---|---|---|
| | | 75-79 years | | | |
| Constant term | 1437.20 | 649.40 | 965.68 | 2.21 | 0.027 |
| Female sex | 42.27 | 8.53 | 1285.41 | 4.95 | <0.001 |
| Calendar year | -0.53 | 0.32 | 966.90 | -1.66 | 0.096 |
| Cage | 10.77 | 0.95 | 833.75 | 11.23 | <0.001 |
| Cage$^2$ | 1.16 | 0.71 | 682.52 | 1.63 | 0.103 |
| Female sex × cage | -6.58 | 5.02 | 640.03 | -1.31 | 0.191 |
| Female sex × cage$^2$ | -2.71 | 1.99 | 657.75 | -1.36 | 0.174 |
| | | 80-84 years | | | |
| Constant term | 2022.93 | 1351.00 | 203.00 | 1.49 | 0.136 |
| Female sex | 144.36 | 51.89 | 172.74 | 2.78 | 0.006 |
| Calendar year | -0.86 | 0.67 | 201.85 | -1.28 | 0.199 |
| Cage | 37.32 | 11.20 | 288.50 | 3.33 | 0.001 |
| Cage$^2$ | -2.06 | 1.09 | 295.82 | -1.88 | 0.061 |
| Female sex × cage | -54.61 | 27.94 | 143.90 | -1.95 | 0.053 |
| Female sex × cage$^2$ | 5.99 | 3.47 | 132.09 | 1.72 | 0.087 |
| | | 85-89 years | | | |
| Constant term | -6922.33 | 3085.79 | 23.60 | -2.24 | 0.035 |
| Female sex | -1921.38 | 1104.14 | 39.30 | -1.74 | 0.090 |
| Calendar year | 4.01 | 1.54 | 23.50 | 2.59 | 0.016 |
| Cage | -148.33 | 59.31 | 20.62 | -2.50 | 0.021 |
| Cage$^2$ | 8.08 | 3.00 | 20.43 | 2.69 | 0.014 |
| Female sex × cage | 419.68 | 254.66 | 39.65 | 1.64 | 0.107 |
| Female sex × cage$^2$ | -22.01 | 14.38 | 39.96 | -1.53 | 0.134 |
| | | 90-94 years | | | |
| Constant term | -10767.13 | 7140.97 | 6.15 | -1.50 | 0.181 |
| Female sex | 51.09 | 80.20 | 4.97 | 0.63 | 0.552 |
| Cage | 4.70 | 3.60 | 6.15 | 1.30 | 0.238 |
| Cage$^2$ | 227.90 | 184.86 | 3.74 | 1.23 | 0.289 |

df, degrees of freedom; Sig, significance

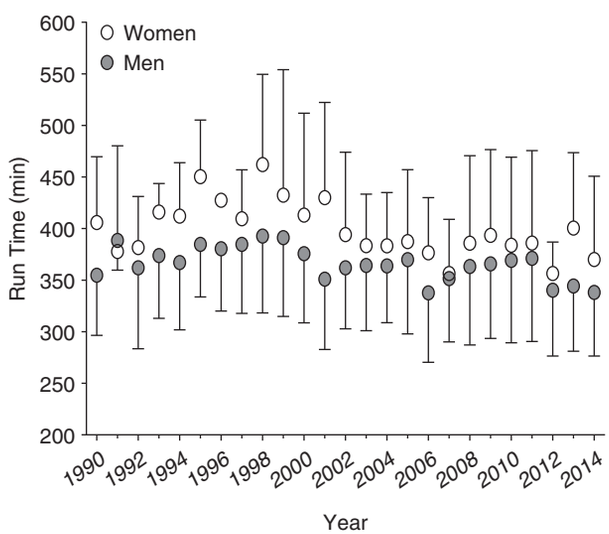


Fig. 4. Marathon race times of female and male finishers in all four races from 1990 to 2014.

in marathon races older than 75 years can be explained by certain demographic developments. There seems to be a large portion of athletes with a relative short training experience. For example, a German study analysing more than 13,000 runners revealed that 42% of athletes older than 50 years were non-active before taking up running (20). Among these, 30% and 25% in the age groups 50-59 years and 60-69 years, respectively, only took up running training in the preceding 5 years (20). If this trend was to continue in the coming years then a considerable number of runners with a 10-20 year experience will reach their 70ies and compete in the older age groups. Therefore, we may assume that the increased participation of older athletes in marathon races will be ongoing in further years.

*Performance Trends*

A second important finding was that runners older

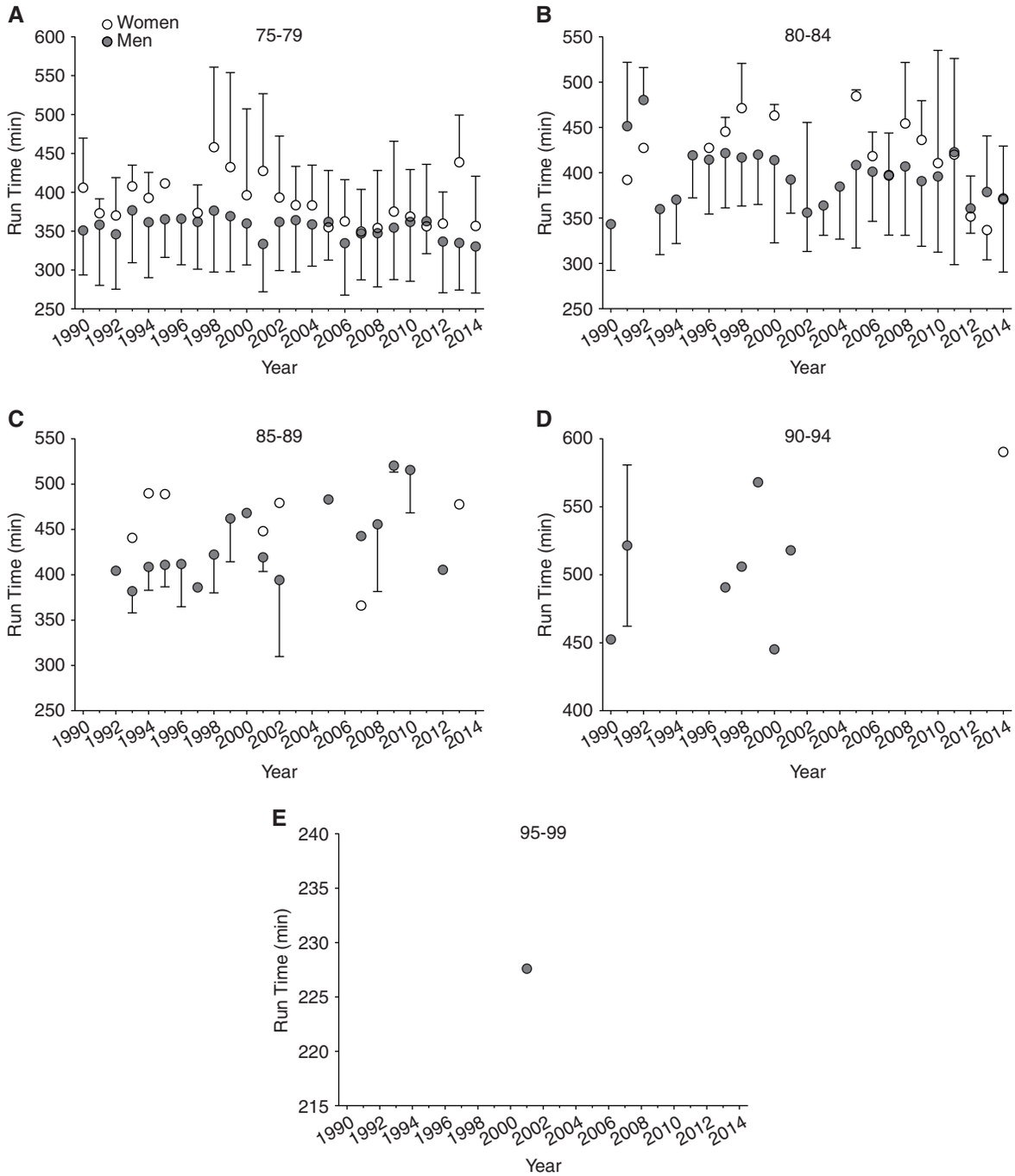


Fig. 5. Marathon race times of female and male finishers in age groups 75-79 years (Panel A), 80-84 years (Panel B), 85-89 years (Panel C), 90-94 years (Panel D) and 95-99 years (Panel E).

than 75 years decreased their marathon race times over the last ~25 years where, however, only women and men in age group 75-79 improved. In addition to earlier findings that age group marathoners younger than 75 years improved marathon race times in the last ~30-40 years (11, 17, 18), these geriatric runners older than 75 years were also able to improve performance in the last ~25 years. Based on the consideration that an increased number of participants should lead to better performances of top athletes, we were interested if the race times in the older age groups decreased over time. We observed strong effects of sex, age and calendar year of the race on the marathon race times. Considering the running performance of all finishers, we could not identify interaction effects of sex and age. In women and men in age group 75-79 years, we detected effects of sex, age and calendar year of the race on marathon race times where men were

faster than women. This result is in agreement with the findings of Lepers and Maffiuletti (16) observing an increase of performance differences between men and women in ultra-endurance events from the age of 55 years on upwards.

*Sex Differences*

A third important finding was that the sex difference in marathon race times remained unchanged across calendar years. Generally, the sex differences increase with increasing age in marathon running (8, 15). However, the present findings differ from the findings in Lepers and Cattagni (17) investigating marathon race times of the fastest female and male age group runners aged between 20-79 years competing in the 'ING New York City Marathon' between 1980 and 2009. They found that the sex difference in marathon race times decreased over the three decades but remained relatively stable across the different age groups during the last of the three considered decades (17). The sex differences in marathon race times were significantly lower for decade 2000-2009 compared to both previous decades independent of the age of the athletes (17). The sex differences in marathon race times were 28.4 ± 10.3%, 25.8 ± 6.9%, and 19.7 ± 4.2% for decades 1980-1989, 1990-1999, and 2000-2009, respectively (17).

In the study of Lepers and Cattagni (17), the sex difference decreased in age groups older than 45-49 years over the three decades. During 1980-1989, the sex differences were greater in age groups 55-59 and 60-64 years as compared to all younger 5-years age groups from 20-29 to 50-54 years (23). Additionally, the sex differences did not differ across age groups for the last two decades 1990-1999 and 2000-2009 (17). Lepers and Cattagni (17) found a significant interaction for sex difference in marathon race times for age group × decade while we found no interaction for sex difference in marathon race times. These disparate findings might be the results of the different time periods and the different sample sizes of the studies.

*Potential Reasons for Performance Improvements for Elderly Marathoners*

Apart from a large range of individual factors like anthropomorphic, genetic, socio-economic and environmental characteristics (21, 22, 28, 29, 33), the limitations of long-distance running performance can predominantly be assigned to exercise intensity at the lactate threshold (5, 13, 31), muscle strength (30) and maximal aerobic capacity (4) with an emphasis on the latter. Each of these three factors contributes to running performance and peak at approximately the age of ~30-35 years (7, 31). Later in life, exercise intensity at the lactate threshold, muscle strength as well as maximum oxygen uptake ($VO_2max$) and thus running times, decline modestly until the age of ~50-60 years. From the age of 60 years on, the decrease in speed is substantially accelerated due to faster age-related degenerating processes (31). Nevertheless, there is an increasing number of aged marathon finishers with observable improvements of running times over the last ~30 years (17). Lepers and Cattagni (17) confirmed a reduction of the mean running time of ~17 min in the age group > 70 years (males) from 1980-2009 in the 'ING New York City Marathon'. Interestingly, they found no significant reduction in the groups younger than 60 years (17). It is still not clear if the mean absolute marathon limiting times in the respective age classes (> 70 years) are reached by now or if a further reduction is possible.

Considering socioeconomic and demographic trends in at least the developed countries, plus the broad implementation of science based training and nutrition regiments, it is plausible to assume a further improvement of both mean as well as top winning marathon times. Furthermore, it would be interesting to examine the optimal starting point for achieving record times as an aged athlete. It is an open question whether records in the high age classes are only achievable for elite runners, who have maintained maximal possible performance throughout their lifetimes into their 70s, or if amateur athletes taking up running later in life are at an advantage. Some of these questions can be addressed through analysis of 'big data' extracted from worldwide marathon events. Finally, in view of training regimes for athletes, it would be helpful to have prediction tools in order to define realistic potential outcomes based on individual anthropomorphic and genetic factors as well as running performance and experience characteristics.

In summary, this study is the first to examine the increased participation and improved performance in marathoners aged 75 years and older in the last ~25 years by investigating marathon race times achieved in four of the largest city marathons as part of the 'World Marathon Majors' held between 1990 and 2014. Participation increased and performance improved in female and male marathoners competing in age groups 75-79 to 95-99 years where the largest increase in participation and the largest improvement in performance were found in age group 75-79 years. The sex differences, however, remained unchanged. Based on these observations we speculate that the participation in international marathon races will further increase in age group athletes older than 75 years with presumably more male than female athletes. Moreover, mean marathon race times of female and male athletes older than 75 years are likely to further decrease in the coming years.

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