

PEAK PERFORMANCE AGE IN SPORT

1. INTRODUCTION

Chances are you'll remain healthier and fitter for longer than your grandparents. Across the world, healthy life expectancy has never been higher. And instances of inspiring veteran athletes still at the top of their game suggest that such patterns may also appear in elite sport.

So, to what extent do optimal ages of athletes differ by sex, sport, and over time? Analysing these patterns can provide insights for understanding elite sports as well as inform us mere mortals about how human abilities change with advancing years.

Besides firing our enthusiasm for sport, such insights can also guide training plans, benchmark performance, and help athletes transitioning between sports (Allen and Hopkins 2015).

There are different ways of estimating peak physical performance outcomes, including by looking at world records by age or tournaments won. Here we look at participation at the top level, in both the Olympics and in professional sport.

Olympics are fertile ground for such an analysis. Since its rebirth in 1886, the summer Olympics has evolved to encompass over 30 sports, with over 10,000 participants, from over 200 countries.

Athletes of all ages participate. In Tokyo, two thirds were in their 20s and about 90% were under 30. Some were as

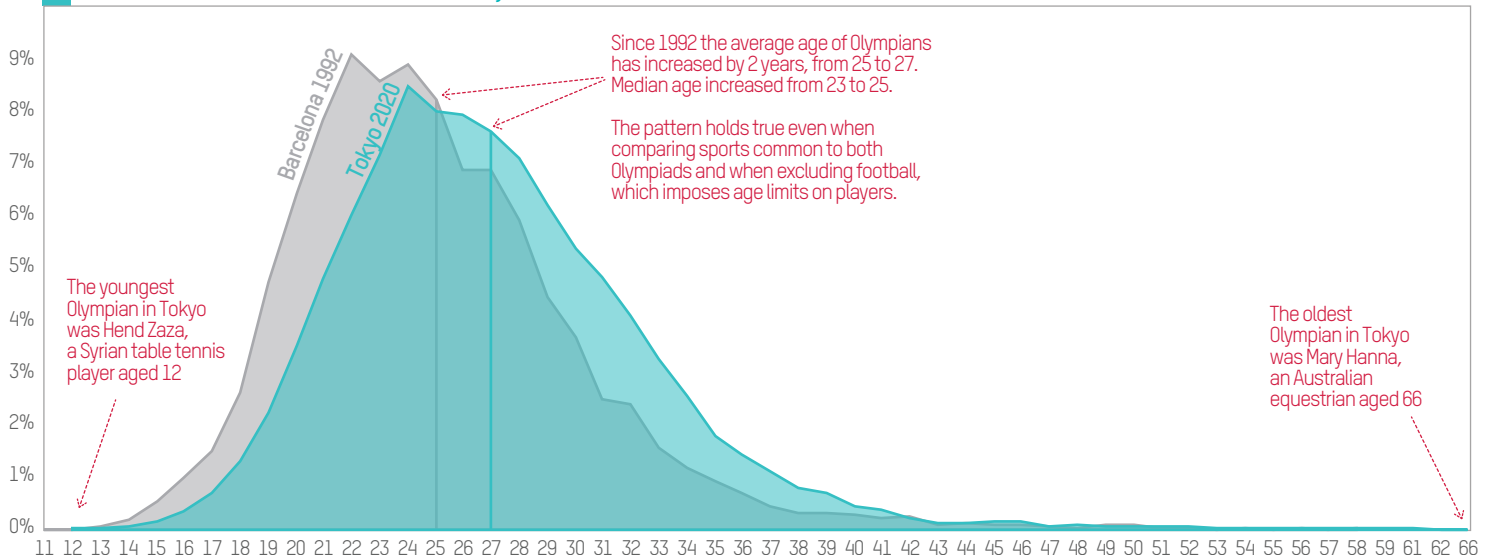
young as Hend Zaza, a 12-year-old table tennis player from Syria. The youngest athlete to ever compete was 10-year-old gymnast Dimitrios Loundras in Athens 1896.

The oldest athlete competing in Tokyo was 66-year-old Australian equestrian, Mary Hanna. She is the second oldest Olympian in modern history, after Oscar Swahn, a Swedish shooter who was 72 when he won silver at the 1920 Games in Antwerp. Hanna was joined in Tokyo by equestrian Andrew Hoy, 62, who won silver for Australia at what is his eighth Olympics over more than three decades.

These decades have also been a time during which the typical Olympian has become older (Figure 1). Since 1992, the average age of participants increased by two years, from 25 to 27. The median age increased from 23 to 25. This ageing pattern holds true even when comparing sports common to both Olympiads and when excluding football (soccer), which imposes age limits on players.

The analysis in this Fact Sheet looks at these patterns in detail. It brings together existing literature and the latest data to illustrate the optimal ages at which physiology, training, and strategy combine for different sports for both men and women, and how this is changing over time. Analysis relies on data from the Olympics as well as from four popular professional sports: tennis, cricket, association football (soccer), and Australian rules football. Finally, a comparison of age distributions in community sports shows how sport is the domain of every age group.

1 AGE DISTRIBUTION OF OLYMPIANS, 1992 AND 2020



Note that all data sources for charts are listed in references

2. COMPARING OLYMPIC SPORTS

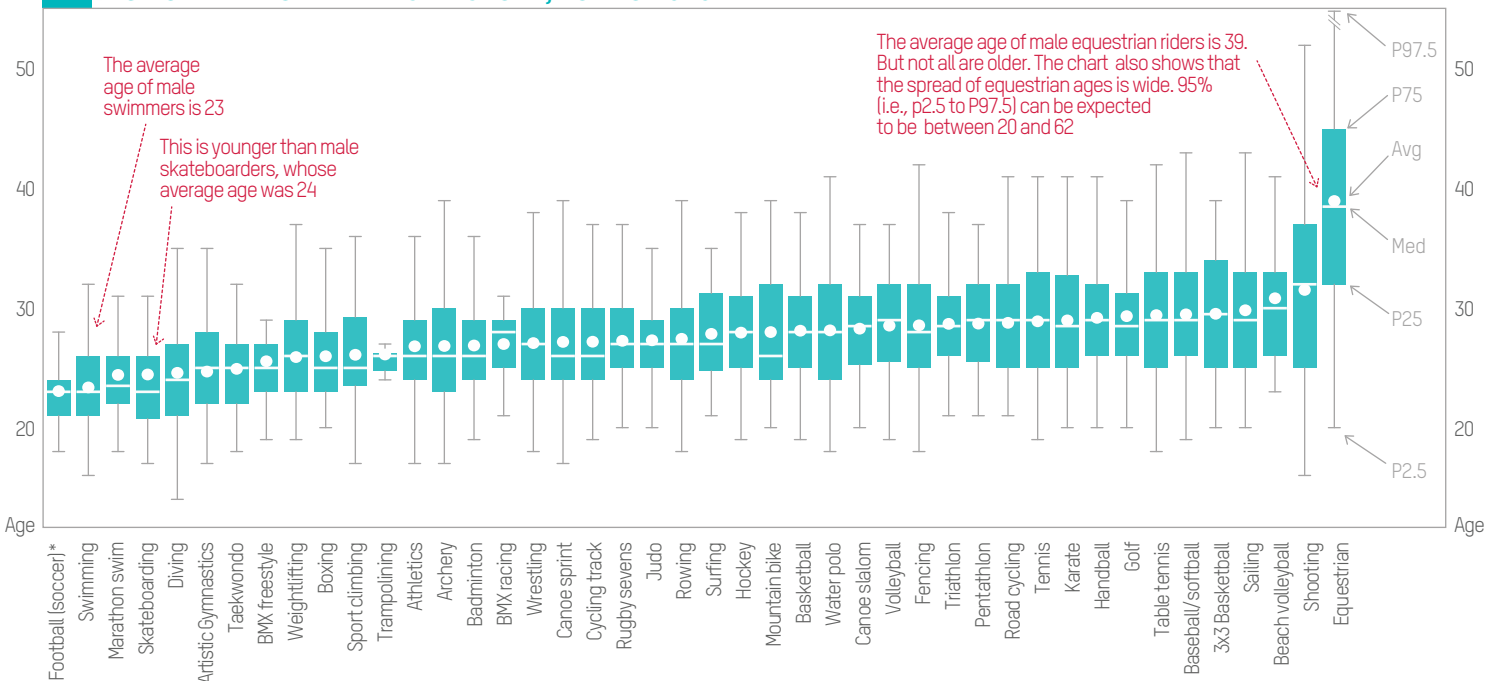
The ages of elite athletes differ by sport. A key driver is how skills and abilities at different ages match the requirements of the sport. Athletes in sports requiring *speed and power* tend to peak by their mid-20s, those in *endurance* sports peak by their 40s, while those in *tactical, low impact* sports can still compete at elite level in their 50s (Gillan 2018; Longo et al. 2016). It chimes with findings on cognitive capacity: young people are better at tasks requiring raw processing power while older people excel at strategy (Chomik et al. 2018).

The 2020 Olympics are illustrative (Figures 2A and 2B). Athletes in sports relying on speed, flexibility, and maximal oxygen consumption such as swimming had the lowest ages (median and average of 23 for men and 22 for women). Tactical and precision sports with lower physical loads such as sailing, shooting, and equestrianism had the oldest ages. The median age for equestrians was 35 for women and 38 for men. The averages were higher still, at 39 and 36.

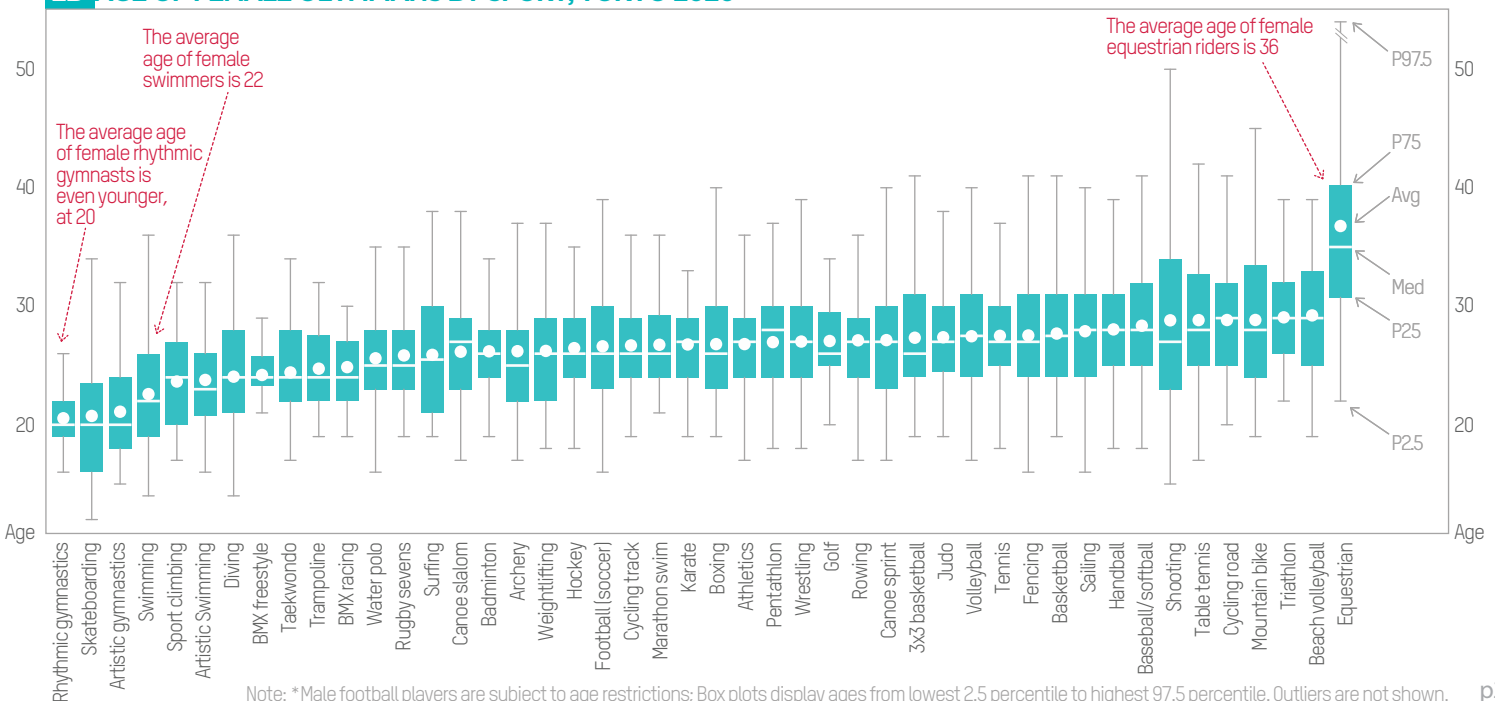
Men's football (soccer), with a median age of 22, is an unusual case. Its governing body limits players over 24 in each Olympic squad. Women's Football has no such restrictions so the average and median age of 25 are a better reflection of peak age of female footballers (see Section 6).

Overall, male Olympians tend to be older, with an average age of 27 compared to 26 for women. Sports with the largest gender difference include golf, sailing, gymnastics, and boxing. In fact, 17 of the 46 sports have a statistically higher peak age for men, compared to just one sport for women (football). The differences could be due to physical attributes. Rüst et al. (2012) cited that differences in body fat, drag, limb length, and body height help explain why women peaked earlier than men in swimming. It may also relate to normal loss of muscle with age – women have less, so lose it earlier.

2A AGE OF MALE OLYMPIANS BY SPORT, TOKYO 2020



2B AGE OF FEMALE OLYMPIANS BY SPORT, TOKYO 2020



Note: *Male football players are subject to age restrictions; Box plots display ages from lowest 2.5 percentile to highest 97.5 percentile. Outliers are not shown.

3. COMPARING OLYMPIC EVENTS

Peak age of performance can differ significantly across events within a single sport. Figure 3 shows the age distribution of swimmers, runners, boxers, and shooters for different events in each sport. It is based on pooled data from the last six Olympiads, between 2000 and 2020.

Take freestyle swimming; median and average ages of male swimmers reveal an inverted u-shape with distance. Typical swimmers in the shorter (50m) and longer events (800m and 1,500m) are older than those participating in middle distance swims (200m and 400m).

Indeed, the 50m dash features the widest age range and oldest swimmers in the swim events, with participants as young as 16 and as old as 37. It could reflect the accessibility of the shorter swim. In Tokyo, 154 swimmers swam the 50m and only 61 the 1,500m.

In running, the relationship between age and distance is also u-shaped. Runners in shorter (100m and 200m) and longer events (1,500m+) tend to be older (median age of 25) than those in middle-distance events (400m and 800m; median age of 24). As with the shortest event in swimming, the 100m sprint includes a wide range of ages, with some athletes as old as 40. Usain Bolt was 30 years old when he won gold medals in 100m and 200m in 2016.

But unlike in swimming, where the oldest of the competitors (who are still relatively young) are racing the shortest distances, the oldest runners are racing the longest distances. This pattern is also evident in data for women and in other research (Allen and Hopkins 2015).

The general pattern highlights that age mediates the trade-off between explosive power and endurance. That is, power relies on stronger fast-twitch muscle fibres more prevalent in the muscles of younger athletes, while endurance relies on less fatigue-prone slow-twitch muscle fibres more prevalent in the muscles of older

athletes (Powers and Howley 2012; Akasaki et al. 2013). Other factors reinforce this pattern. For example, age-related decreases in the maximum oxygen consumption, heart rate and stroke volume, and rate of removal of blood oxygen favours younger athletes in shorter, high-intensity activities (though such declines also affect endurance running; Tanaka and Seals, 2008). Also, “*experience, pain management, decision-making, and motivation and psychological disposition*” play a greater role in endurance events, favouring older athletes (Tiller et al. 2021).

Over the last two decades, the median and average age for the Men’s Marathon was 30, well above any other event distances. The Marathon also features a long tail of older runners, with the oldest competitors out of any running event. In 2020 the oldest male Marathon runner was 46. Female Marathon runners were typically older still (not shown), with a median and average ages of 32 and 31; the oldest in 2020 was 44.

In sports such as boxing and weightlifting, athletes are divided into weight classes. Olympic data suggests that generally, as weight class increases, so does the mean age. This may relate to maturation age of both upper and lower body muscles and the idea that as weight of a boxer increases, there is a greater emphasis on strength and less on speed (though research is scarce; Chaabene et al. 2015).

Finally, sports where emphasis is less on physical attributes and more on exceptional skill can favour older competitors. This is evident in shooting events. Rifle events, which involve stationary targets (e.g., air rifle), tend to have lower median and average ages than shotgun events, which involve moving clay targets (trap, where targets move away from the shooter, and skeet, where they cross from the sides). For example, while Men’s Trap has a median age of 35, Men’s Air Rifle has a significantly lower median age, at just 28.

3 AGE OF MALE OLYMPIANS BY SPORT AND EVENT, 2000-2020



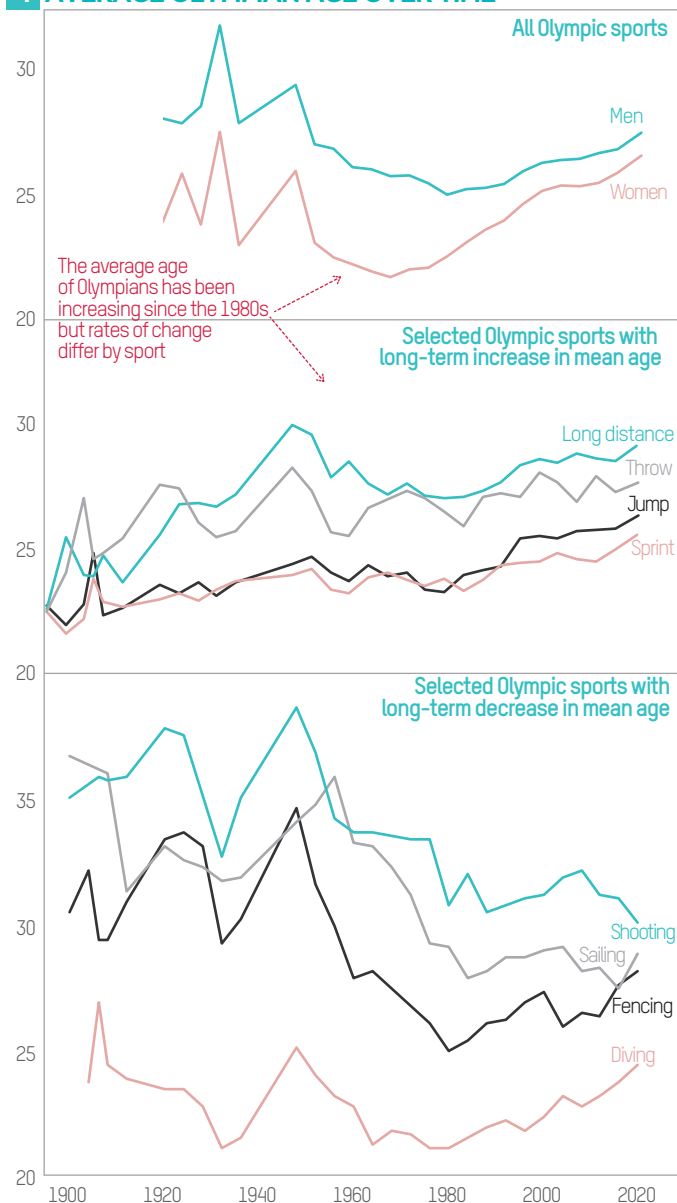
4. OLYMPIC SPORTS OVER TIME

Of particular interest is the change in peak performance age over time. The inaugural modern Olympics, in 1896, featured the youngest competitors on average, with a mean age of 23. However, data from early Olympics is sketchy. It excluded women and had few competitors.

Figure 4 shows average ages of Olympic athletes since 1920, but the pattern represents a broken series. That is, for many decades, the average age was affected by compositional change. For example, women did not compete until the 1920s and not significantly until much later.

There was also an increase in the variety of sports represented. For the first half of the 20th century, the majority of participants competed in athletics, which favours younger athletes. At the 1932 Los Angeles Olympics, the now-defunct *Art Competitions* event was popular, with medals for sport-themed art. Forty-five people competed – the second-highest participation level behind athletics – with a mean age of 48, evident in a spike in average age at that time. Declines in average age since World War II were in part due to the popularity of gymnastics and swimming and in part because of the demography of a post-war world.

4 AVERAGE OLYMPIAN AGE OVER TIME



The 1980s were a turning point. From that point, professional athletes were able to compete in the Games. Trends since then may be more representative of a genuine increase in peak performance age in elite sports. Between 1992 and 2021, average ages of male Olympians increased from 25 to 27 and female ages increased from 24 to 26. Older athletes are not just participating, they're winning medals. Average ages of participants broadly coincide with ages of medal winners over time (not shown).

Though doping casts a shadow over every Olympics, the ageing trends are typically put down to improvements in medicine, sports science, innovations in sport equipment (e.g., shoes, bikes etc.), and training regimes. It also parallels change observed in wider society of longer, healthier lives.

The average age trajectories of individual sports (bottom panels of Figure 4) are less affected by compositional factors. In general, these reveal an increase in the average age of elite competitors, but not consistently for all sports. Within athletics, for instance, the typical sprinter and jumper has been getting progressively older over time, whereas the typical long-distance runner is older now than in the 1980s but younger than in the 1950s. An increase in average age is also evident in many other sports, such as boxing, cycling, and basketball (not shown).

By contrast, sports such as archery, diving, sailing, and fencing experienced a downward trend in mean age over time. Indeed, archery is one of very few sports that declined consistently throughout the time. Most other sports that declined overall, experienced periods of both increasing and decreasing peak ages. For instance, in diving, the peak age fell to a low of 20 in the 1970s and has been increasing slowly ever since.

A few sports experienced a decline in peak age from 1948 to 1968. But again, age data from earlier Olympics may be affected by other factors. For example, changes could reflect an increasing accessibility of certain sports driven by the advent of television. In turn, this could raise the possibility that people could specialise in these sports at much younger ages than before. Additionally, many countries' athlete pool was affected by World War II. And restrictions on professional athletes before the 1980s will also have affected the trends – in the past, amateurism meant that the games were dominated by the wealthy. In fact, even among the sports that declined in peak age, most saw a slight increase from 1988 onwards.

Another feature of the average age trends is the convergence in ages between men and women. Until 1980, males and females differed in peak age by 3 to 4 years (though in 1932 the difference was over 6 years). More recently, the gap between men and women in terms of peak age has shrunk to approximately 1 year. In some sports, women have reached age parity (athletics, canoeing, and judo) or even become older on average (cycling).

Gymnastics is one of the few sports in which a large age discrepancy between men and women remains, which may reflect differences in physiology, rates of maturation by age (Barrell 2018; Sissons, 2020), and event type (only men compete in the strength-intensive Pommel Horse, Rings, and Parallel Bars).

5. TENNIS

Tennis is a sport rich in change. Changes in technology, rules, surface, playstyle, training, as well as player health have given rise to distinct trends in peak performance age.

Serena Williams and Roger Federer, both turning 40 in 2021, are remarkable examples of the potential longevity of top athletes in Tennis. Both their tennis careers have benefited from improvements in medical technology, for example. But to what extent do they represent a broader trend in tennis?

Figure 5 reveals the age distribution for the top 100 men's tennis players every three years from 1970 to 2021. The figure shows an initial decline in median age from 27 in the mid 1970s to 24 in the late 1980s. Since then, the median and average age for male tennis players has increased to 28 by 2021.

Women tennis players tend to be younger than men, in part due to differences described already, and perhaps in part because the game is different: in Grand Slams they compete in best-of-three sets compared to men's best-of-five sets, which require marathon-levels of endurance. Still, changes over time reveal similar patterns. The 1980s saw a sharp increase in age, from an average and median of 20 to 22 by 1991, and to 26 now.

It's worth noting that within the top 100 some younger players are yet to peak while some may have already peaked but are yet to retire. Analyses of historical wins and losses as well as grand slam titles within the group suggest that peak performance age may be lower (e.g., 23 for men and 21 for women, on average; Davey 2014). But trend analyses on this basis are lacking.

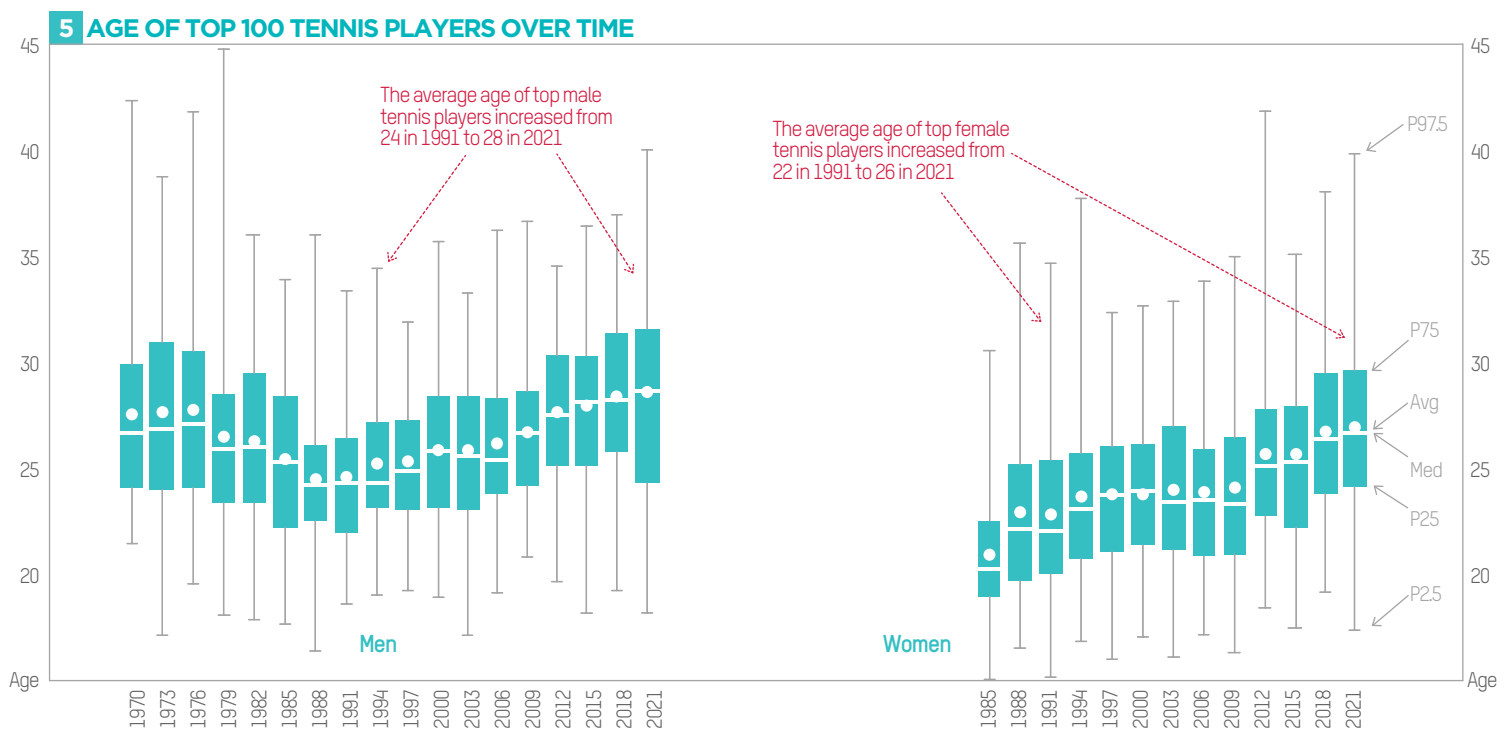
Past average age declines seen in the top 100 data for men may be partly attributed to improvements in technology, in which racquets produced from the mid

1970s were more powerful than before, but it's unclear why these would advantage the young. It's more likely that initial declines and subsequent increases in age are typical of the process of professionalisation. In tennis this involved the establishment of the Open Era of tennis in 1968, when professional athletes were invited to participate.

Professionalisation meant that prize money for tennis rose dramatically. For example, for women it increased, "from \$250,000 in 1971 to \$7.2 million in 1980, and \$23 million in 1990" (Galenson, 1995). This meant that players could make tennis their lifelong career, first entering the sport at earlier ages and then delaying their retirement until later. This coincided with increased opportunities to play tennis (Alfano, 1989) and the rising popularity of the game (Galenson, 1995).

The ageing of the top 100 men and women observed in the more recent decades may be attributed to a continued shift in racquet technology and game style. For example, tennis play has largely moved away from the explosive athleticism of a serve-and-volley strategy, in which players move to the net immediately after serving. Instead, the backcourt style has become popular (Kovalchik, 2014), putting more of an emphasis on power that can be generated from better raquets (Gallo-Salazar et al., 2015) and endurance, a domain of older athletes.

Recent rule changes such as the opportunity for players to skip one Masters 1000 tournament without financial penalty may improve player longevity for years to come. This is because older bodies may still be able to perform at a high level but require more time for recovery.



6. FOOTBALL (SOCCER)

Association football, or soccer, is the most popular sport in the world, played and followed by over 4 billion people (statisticsanddata.org, 2020).

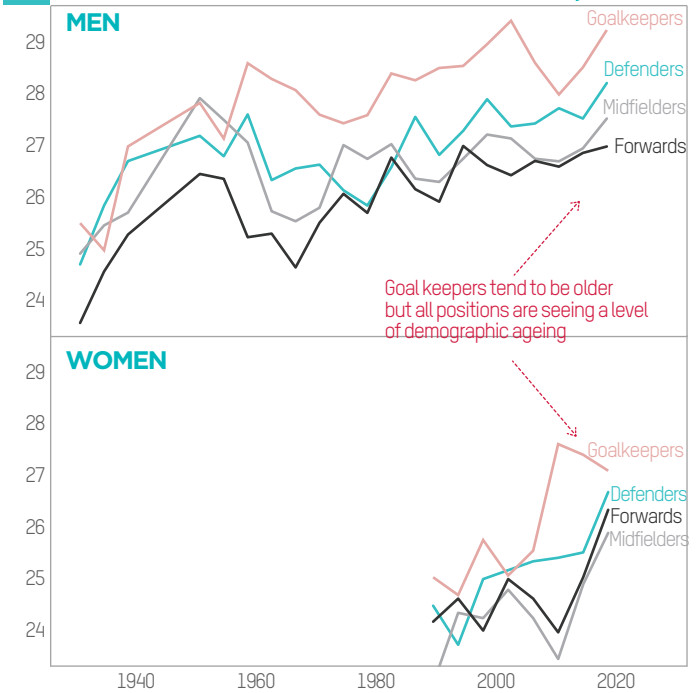
Figure 6A reveals how the ages of FIFA World Cup players have changed over time. For men, the average and median age initially rose from 24 in 1930 to 27 in 1950. As with other sports, this may reflect professionalisation of the game in several countries at that time, including Spain in 1926, Argentina in 1931, France in 1932, and Brazil in 1933 (Goldblatt, 2006; Bellos, 2002). In addition, World War II affected the younger populations of many countries, forcing them to field older teams in 1950. The average and median age then fell to 26 and 25 in 1962 as countries rebuilt their younger populations before increasing slowly until today. At age 27, the typical top male football player is now only one year older than was the case in 1990.

Although the Women's World Cup has only been in existence since 1991, it has already witnessed an upward trajectory in average and median age, which rose from 23 in 1991 to 26 in 2019.

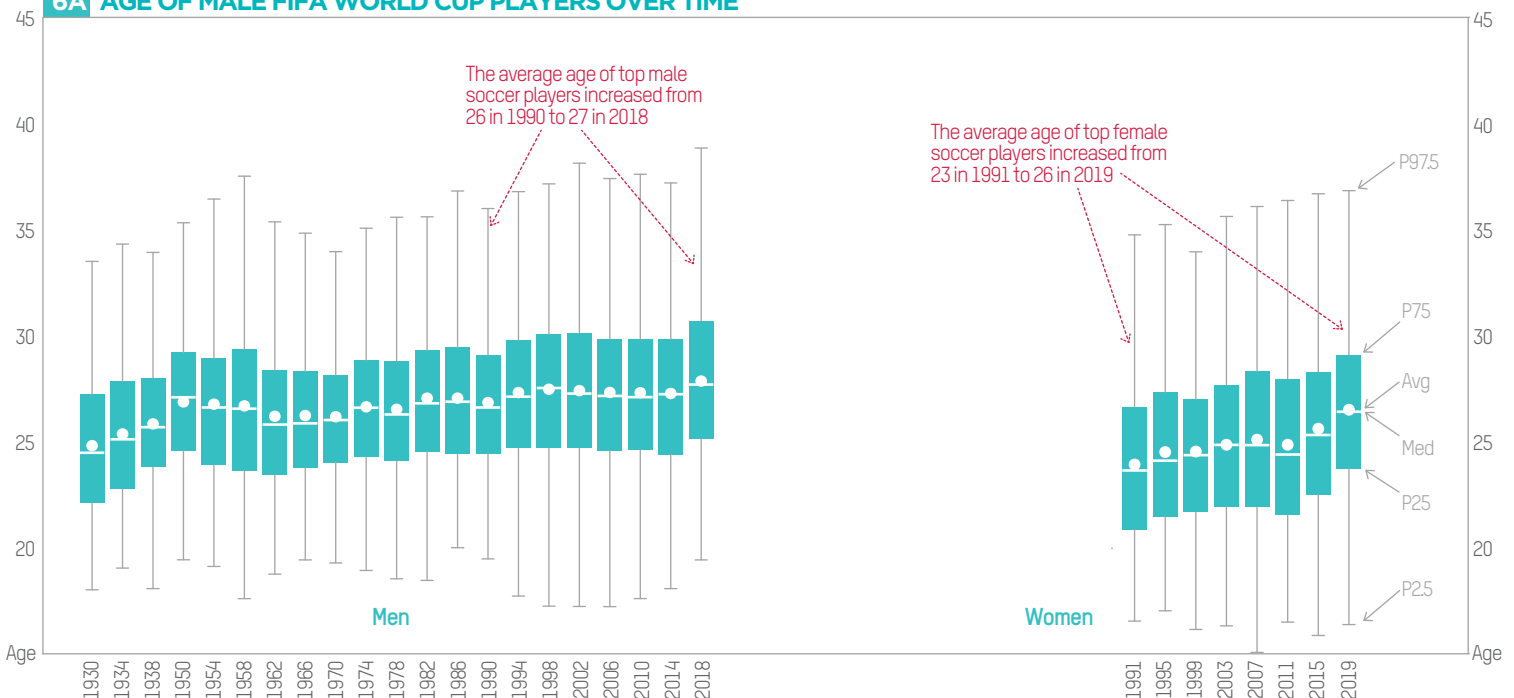
Distinct differences in peak age can also be seen when comparing age trends by position. Past research found that forwards peak around age 25, defenders at 27, and midfielders somewhere in between (Dendir 2016). Dendir links these to the fact that forwards need to run and shuffle, endure more physical contact, and require more explosive power. Defenders are more stagnant during a game. Hence, defenders benefit most from "acquired learning and experience". Age-related projections of career performance by player type are not uncommon in professional sports (Silver 2003).

Here we extend the analysis to goalkeepers (Figure 6B) in both the men's and women's game. Goalkeepers are the oldest player type, followed by defenders, midfielders, and then forwards. Indeed, although goalkeeping requires significant agility and reaction time, traits benefiting older players, such as psychological resilience (Laws, 2006) and strategic decision-making (Otte, 2019) are also important. These skills are thought to develop with experience and age. Their greater playing longevity may be because they are specialised both in skill and body type: they're often taller.

6B MEDIAN AGE OF FIFA WORLD CUP PLAYER, BY POS.



6A AGE OF MALE FIFA WORLD CUP PLAYERS OVER TIME



7. AUSTRALIAN RULES FOOTBALL

Few studies have looked at peak performance age in the Australian Football League (AFL). The longevity of AFL players has been a point of discussion in recent years, particularly with players such as Dustin Fletcher, Brent Harvey, and Shaun Burgoyne reaching their 400th game, a feat matched by few in the history of AFL.

As shown in Figure 7, the average and median age of male AFL players increased from 23 in 1967 to 25 in 1983. The period coincided with growing professionalisation of the sport. Following player strikes in 1970, contracts that paid a liveable wage became increasingly common throughout the 1970s (Roberts, 2020; Booth, 2005).

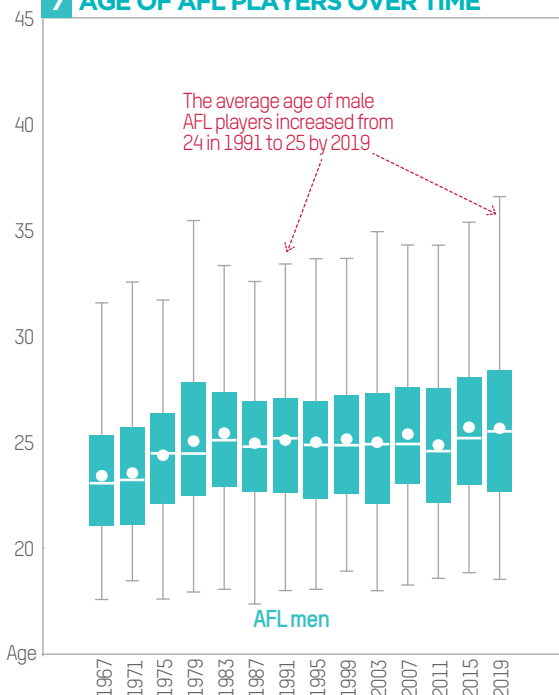
The median age of male AFL players has remained relatively stable around age 25, though maximal and average ages increased slightly. The average age increased from 24 in 1991 to 25 in 2019.

The stable age of 25, lower than in tennis, football, and cricket, may reflect the fact that AFL is a multi-skill sport. Speed is required for moving across the 155-170m long playing field; strength is required to *mark* the ball from the air, muscle opponents out of the way, and when tackling. The greater contact and impact means that there is a greater premium on fast recovery, which is more difficult at older ages.

A 2020 study revealed that AFL ruckmen, i.e., tall players who engage in contests similar to a tip-off in basketball or a line-out in rugby union, tend to peak at older ages (27) than other players (24-25; Sullivan et al, 2020), probably because height is less subject to age declines. Future studies could explore the differences between other players (defenders, midfielders, and forwards).

The women's Australian Football League is relatively new and has limited data. But in 2021, the age distribution was like that of men, with ages ranging between 18 and 39 and the mean and median age of 25.

7 AGE OF AFL PLAYERS OVER TIME



8. CRICKET

Cricket can be played in different formats. These range from *Twenty20* (a fast-paced, high-action format) to *Test matches* (a slow-paced, traditional format played over five days). Here, we look at the *One-Day International* (ODI) format, which is played over a single day — longer than the Twenty20 format but shorter than Tests.

The typical cricket team consists of batters, bowlers, and wicketkeepers, who aim to catch the ball after it has been bowled and to get batsmen out. Some both bat and bowl so are aptly named all-rounders. The skills required of a batsman differ to that of a bowler, and hence it would make sense to compare their age trends.

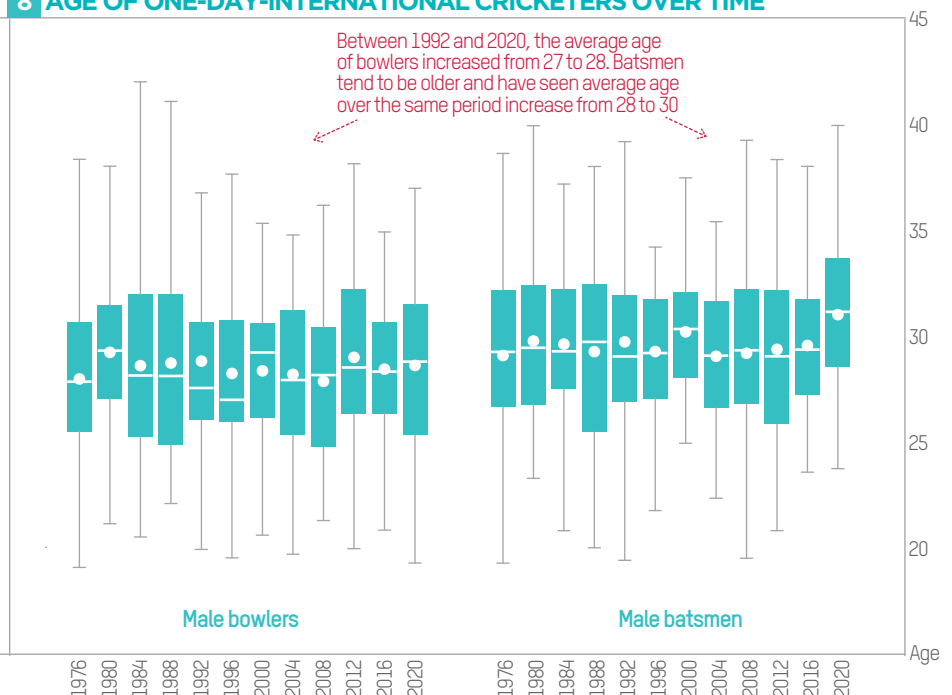
For batsmen, the median age has remained stable since the 1970s at around 28 to 29 years of age for most years. In contrast, the median age for bowlers declined from 29 in 1980 to 27 in 1996, before rising gradually to 28 in 2020.

Batsmen have consistently been older than bowlers. This may be because bowling requires speed and power, skills that, as mentioned previously, peak in one's twenties.

Bowlers can be further categorised into seam bowlers, who use raw power to bowl quickly, and spin bowlers, who bowl slowly but aim to beat the batsmen by way of accuracy and spinning the ball. Despite potentially different skills, there is no significant difference in ages between seamers and spinners. Still, some studies show that as seam bowlers age, they tend to shift from being out-and-out pace bowlers towards a more accurate style of bowling (Thorley, 2021).

Comparing the professional sports presented here suggests that AFL players tend to be the youngest, followed by soccer, tennis, and cricket players. It highlights the insights that higher impact sports requiring strength and speed favour younger players, while endurance and precision develop later. It also suggests that most sports are seeing a level of ageing.

8 AGE OF ONE-DAY-INTERNATIONAL CRICKETERS OVER TIME



9. COMMUNITY SPORTS

In elite sports, peak ages of participation and performance tend to coincide. This is not necessarily the case in community sports, where enthusiasm and ability to take part are more important than performance. So, what does sport participation by age look like in the community?

In Australia and elsewhere, participation in sport tends to peak by age 15 and declines through adulthood and old age (Eime et al. 2016). Yet the typical sports participant is ageing fast. This is not only because there are more older Australians, but also because they are playing more sport.

Whether measured based on taking part once a year, weekly, or three or more times per week, the rates of older people participating in sport have been increasing. In 2000, about 40% of men and 30% of women aged 65+ reported playing sport that year, about half the rate of those aged 18-24. But by 2020, participation has converged across the sexes and age groups, with rates ranging 86%-92% (ABS, various years; SportAus, various years). These days, weekly sport is less common for those in their late 20s than for older age groups.

As with elite sports, community sporting activities attract different age groups to different degrees. Walking is the most popular – about half the Australian adult population took to recreational walking in 2020, with older age groups over-represented.

Figure 9 illustrates the age share of the 30 most popular sports in Australia. These range from high impact sports dominated almost exclusively by young people (e.g., volleyball, basketball, and rugby) to those where older people make up the largest share of participants (e.g., fishing, golf, and bowling). In between are sporting activities dominated by those in middle age (e.g., surfing, gym, and tennis). There are likely to be many social, psychological, functional, cohort, and socio-economic reasons for such outcomes. Most importantly, the results show that participation in sport can take place at any age, regardless of the typical age of peak performance.

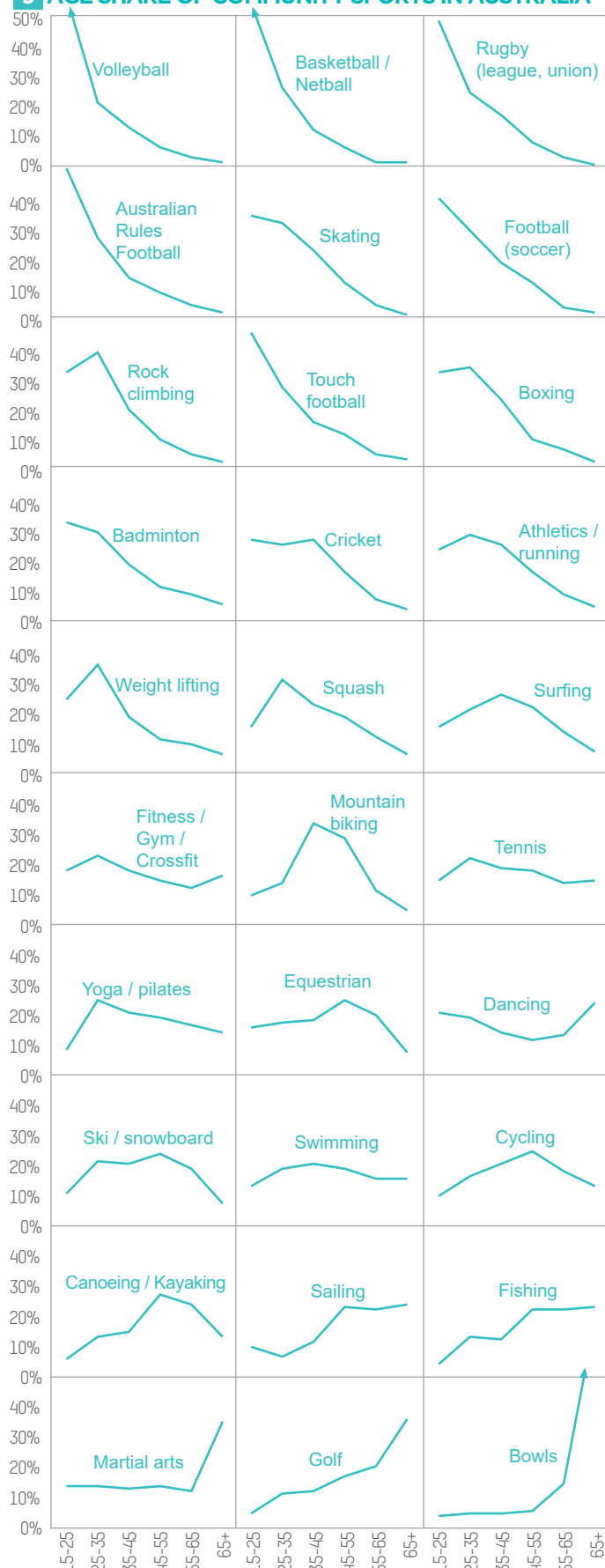
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DATA SOURCES

- Olympics: <https://www.kaggle.com/heesoo37/120-years-of-olympic-history-athletes-and-results>
- Olympics: <https://olympics.com/tokyo-2020/olympic-games/en/results/all-sports/athletes.htm>
- ATP: <https://www.ultimatetennisstatistics.com/rankingsTable>
- ATP: <https://www.atptour.com/en/rankings/singles>
- WTA: https://github.com/JeffSackmann/tennis_wta

9 AGE SHARE OF COMMUNITY SPORTS IN AUSTRALIA



Dominated by younger participants

Dominated by older participants

- Cricket: <https://www.icc-cricket.com/rankings/mens/player-rankings/odi>
- Football: https://en.wikipedia.org/wiki/2018_FIFA_World_Cup_squads
- AFL: <https://aiftables.com/afl/stat>
- Womens AFL: <https://womens.afl/teams>
- ABS: <https://www.abs.gov.au>
- SportAus: <https://www.clearinghouseforsport.gov.au/research/ausplay/results>