Sports Analytics: Explore Player Careers

Exploring Peak Age in Professional Sports Careers through Machine Learning and Analysis

Bobbi McDermott
Department of Computing
Atlantic Technology University
Co Donegal, Ireland
bobbifrances@gmail.com

Brid McDevitt
Department of Computing
Atlantic Technology University
Co Donegal, Ireland
brid.mcdevitt@atu.ie

***Abstract*—The chronological age ranges are, on the whole, increasing for athletes competing at their peak. This is a unanimous finding across the literature referenced in this study. There are exceptions when it comes to specific disciplines and there are opinions when it comes to team sports that are more difficult to support with data. This report examines several different sports to support these hypotheses. The findings are universal in that advancements in technology and medical knowledge are crucial to emerging trends in performance analysis. Analysis of the activity itself provides insight into training advancements. Increased competition and financial profit are driving professional sports persons to compete at a higher level. What is not determined in this examination is how to predict what future performance levels will look like. The physical makeup of players is changing and it is difficult to determine what age group these technological advancements will benefit. This observation very much aligns with the literature that in general, the peak age is increasing, however, every sport needs independent examination as physical prerequisites are varying and there are exceptions to this rule.**

I. Introduction

Sports analytics is a huge industry when it comes to measuring performance in a particular game or setting. It's also used as a tool to view how a particular field is advancing and adapting with time due to clinical headways in training and healthcare, analysis of functionality, prize money at tournaments [1] socio-economic circumstances in education and culture [2].

These change differences can be seen in the physiques of rugby players, higher achievements in Olympic games, and the peak performance age of athletes increasing in all specializations. For instance, in rugby, the average athlete's weight in 1955 was 84.8 kg. On the other hand, it was 105.4 kg in 2015, an increase of 24.3% [3]. The Olympics saw the highest-ever number of medals achieved by one athlete with Michael Phelps achieving 28 in total [4] and since 1992 the average age of Olympians has increased by 2 years, from 25 to 27[5].
The median age increased from 23 to 25 [5].

This increase in age in sports however is not a one-way observation. While tennis players' peak performance ages are increasing, we also see a rising number of younger players moving into pole positions. The balance though in tennis is predominantly older players seeing success in longevity in recent years. Overall the consensus seems to be that these athletes are now able to stay fitter and healthier for longer [6].

It is quite extraordinary in this sport however as the level of fitness required is exceptional and the skill set needed is unique. These players, therefore, have a team of people from coaches, fitness trainers, and physios to achieve such heights [1]. Still, we see the ages of players at their peak increasing, in 2017, five men in their 30s were able to hold the top five positions in the world rankings. Ten years prior, all of the top five positions were held by players in their early 20s and the most recent ATP ranking on 24th May 2021 had Novak Djokovic and Rafael Nadal in this category at 35 years of age [7].

Further examination into other disciplines has revealed that this is not a uniform pattern. Although the age of athletes is increasing, sports such as rugby indicate that performance is relatively stagnant from the ages of 18 to 34 with variations from different positions [8], but generally speaking, top performers ages are between 26 and 28 years old [9].

There is a lot of data and literature that analyses the link between age and performance when it comes to the Olympics but this is more a contemporary look as it's crucial information to improving exactness in any discipline [10]. However, looking at the development throughout the years provides an interesting insight into the advancements and changes that an athlete needs to adapt to and indeed sustain physical acuity. The Olympics can also provide comparisons between men and women, countries, and specializations but the concentration will be on peak age in this consideration.

There are various studies into this arising pattern of age fluctuations in athletes' performance and other reports that look at activity participation of communities overall. This study looks at professional athletes and examines the different trends amongst different specializations, particularly tennis, and rugby, and also looks at the Olympics as they are a hotspot for such an examination [1]. This research will look at these and see how they affect both ends of the age spectrum.

The technology used to look at these observations will be Google Colab and Power BI. These can clean and represent the data in a visual form to confirm the aforementioned hypotheses. Technology in the wider sense has contributed hugely to sports analytics. Athletes now wear sensors in their clothing to convey real-time information on their performance [11], for example, rugby coaches will pull their players once they reach several kilometers run as their performance from there will deteriorate. There are many other utilities that technology contributes to in many sports, most notably instant replay [12].

II. Methodology

To display the results of these findings there have been a few different software's employed to accurately prepare and display the data to reflect the findings, namely CSV datasets, python code in Google Colab, and Power BI.

A. Tennis

To answer the question of when great sports players peak seems to be mostly uniform at any specific time, however, this has changed over the years and therefore this study is looking at two sets of statistics 20 years apart, specifically the Men's ATP Tour 1999 and 2019 respectively. The figures taken were the top 20 rankings in each given year which is a good benchmark of when a player was performing at his best. The data was taken directly from the ATP Tour website so it's 100% accurate. The CSV sheet was cleaned by eliminating irrelevant data and adding in the date of birth for purposes of this investigation. Using the YEARFRAC formula in the CSV established the age of the player at the time of the tournament. This was done in both sheets.

The dataset then was ready to be uploaded to Google Colab using Pandas (*pd.read_csv).* This platform was mainly used to visualize the data. To get a snapshot of how the figures would represent the initial viewpoint from the literature is to find the mean of age groups from the separate years using .mean() as in Fig.1.

```
df2019['Age'].mean()
```

Fig.1

Putting the players' ages into categories using bins and labels helps the process of plotting the data for visualization. This was done by using Panda library in Python. It's important to note that ages on the border of these bins will automatically fall into the lower bracket so using *'right = false'* maintains the integrity of the data for that specific field.

To display on a line plot import pyplot and use the code as displayed in Fig.2

```
from matplotlib import pyplot as plt


plt.rcParams["figure.figsize"] = [7.00, 3.50]
plt.rcParams["figure.autolayout"] = True

ax = df.plot(x='Age Range', y='Age 1999')
df2.plot(ax=ax, x='Age Range', y='Age 2019')

plt.show()
```

Fig.2

Further bar charts using '*plotly.express as px'* gives a further visual to demonstrate the outcome, Fig.3

```
import plotly.express as px

fig = px.bar(df, x=df.index, y=df['Age 1999'], color=df.index,
             barmode="group", title="Age Range Rankings 1999")
fig.show()
```

Fig.3

B. Rugby

Rugby is a more difficult sport to establish peak performance. The literature is uninformed that it hasn't changed but the difficulty lies in two aspects, 1) Different positions have different outputs as to performance and 2) as a team sport there is no measurable method for establishing the peak functioning ability of any one player. Kaggle provides a good dataset that analyses different aspects of achievements in the six nations. This dataset was mainly taken from https://index.rugbypass.com/ and is public domain. The second dataset was drawn from Wikipedia which lists the top points scorers of all time. As Wikipedia is an open-source program, this list was verified by other sources such as www.sixnationsrugby.com/statistics/records

Additional information such as player's career spans was taken from ESPN which gives accurate profiles of rugby players. There would be several viewpoints to take in record statistics when it comes to rugby, for instance, the highest tries scored, but they all yield a similar output when it comes to age ranges and therefore it will suffice to look at points scored for this report. These analytics will be the focus to provide a measurable assessment of opinion in Professional Rugby Player's output.

These two datasets used similar cleaning processes and they were both visualized through Power BI. Neither of these datasets had a 'date of birth' feature for the players, given this report is analyzing peak physical age it is necessary to include this information. Therefore, this information was populated separately onto the CSV file and then uploaded to Power BI.

The age of the Athletes was determined through Power BI using DATEDIFF [13], Fig.4.

```
Age = datediff('POT Info'[Date of Birth ],'POT Info'[Year],year)
```

Fig.4

The age can then be used as the y-axis in visualizing the data. In the dataset 'Player of the Tournament' the year a player won is used as the y axis. A similar process was taken for 'Top Points Scorers'. In both a line graph was used utilizing the visualization banner in Power BI, and titles and color schemes were set up using this feature also. Given the relatively little data, there is on historic performance per player, these two examples give a snapshot of the age range and are remarkably similar in their output.

C. Olympics

The information on the Olympics posed a different challenge to the approach with rugby as the data on it is so vast and there are so many competing different disciplines. It perhaps is a better measurement for differing age ranges for professionals across a wide range of specializations.

The figures were taken from Kaggle, '120 years of Olympic history; athletes, and results, and it was compiled from www.sports-reference.com in May 2018. It's an extensive dataset and aims to examine historic trends between nations and the ratio of men to women. It is useful for this examination as it provides the ages of the athletes, but it is important to cut it down to get a snapshot of time similar to the ranges we looked at for both tennis and rugby. Therefore, the CSV file was cleaned to span the years 1996 to 2016 and only for medal winners in the summer games. This was done using sort and filter as the material begins in 1896. It was further narrowed down to display only medal winners.

Of initial interest was to look at the average age of all athletes using Google Colab by uploading the cleaned CSV using *pd. read_csv* and then drop the columns that are not of interest in this view using *the drop* function. The mean was calculated by grouping the years and the index was reset to align column headings, Fig.5

```
averageage = dfnew.groupby('Year').mean()

averageage = averageage.reset_index()
```

Fig.5

The use of Plotly Express was then used to show a line graph and bar chart outcome. A similar process was used to transform the data into separate frames for males and females to stack these results employing comparison, this was done using two data frames and creating a relationship between them joining 'year' as the primary key. Once these frames were established, Google Colab was used to download the files so they could be visualized in Power BI. Download was achieved using code in Fig.6.

```
from google.colab import files

averageagewomen.to_csv('Olympics Women.csv', encoding = 'utf-8-sig')
files.download('Olympics Women.csv')
```

Fig.6

There are so many aspects to look at when examining patterns in Olympic performance as the information is so vast. Therefore, it was crucial to narrow this down and look at specific disciplines with a closer lens.

To establish what events to concentrate on data was taken from www.topendsports.com, there is clear data as to the top medal winners overall, Fig.7 [4], and the top Gold medal winners, Fig.8 [4]. The clear outcome from this is that the two highest achieving disciplines are a) swimming and b) gymnastics and therefore the main aspect of this analysis will concentrate on these two events.

Top male and female (total medals)

rank	Athlete	Country	Sport	Total Medals
1	Michael Phelps	USA	Swimming	28
2	Larisa Latynina	Soviet Union	Gymnastics	18
3	Nikolai Andrianov	Soviet Union	Gymnastics	15
=4	Boris Shakhlin	Soviet Union	Gymnastics	13
=4	Edoardo Mangiarotti	Italy	Fencing	13
=4	Takashi Ono	Japan	Gymnastics	13
=7	Isabell Werth	Germany	Equestrian	12
=7	Paavo Nurmi	Finland	Athletics	12
=7	Birgit Fischer	Germany	Canoeing	12
=7	Jenny Thompson	USA	Swimming	12
=7	Sawao Kato	Japan	Gymnastics	12
=7	Ryan Lochte	USA	Swimming	12
=7	Dara Torres	USA	Swimming	12
=7	Alexei Nemov	Russia	Gymnastics	12
=7	Natalie Coughlin	USA	Swimming	12

Fig.7

Top Male and Female Athletes (total gold medals)

rank	Athlete	Country	Sport	Total Golds
1	Michael Phelps	Germany	Swimming	23
=2	Larisa Latynina	Soviet Union	Gymnastics	9
=2	Paavo Nurmi	Finland	Athletics	9
=2	Mark Spitz	United States	Swimming	9
=2	Carl Lewis	United States	Athletics	9
=2	Birgit Fischer	East Germany, Germany	Canoeing	8
=7	Sawao Kato	Japan	Gymnastics	8
=7	Jenny Thompson	United States	Swimming	8
=7	Matt Biondi	United States	Swimming	8
=7	Usain Bolt	Jamaica	Athletics	8
=7	Ray Ewry	United States	Athletics	8

Fig.8

It is insightful to get an overall view initially of what age brackets this event is most compatible for. These categories are still vast therefore the csv was cleaned again for two categories, a) men's gold medal winners for 100-meter and 200-meter freestyle and b) women's gold medal gymnastic floor exercises. Included is also an average overall for both sports overall using the same methodology Therefore the consideration will be on the following:

- Average Age of Athletics **Colab**
- Average Age of Swimming **Colab**
- Average Age Overall **Colab**
- Average Age Men v Women **Power BI line and bar graph**
- Overall swimming average
- Men's Swimming **Power BI and Google Colab**
- Floor Gymnastics' Women; age by year **Power BI**
- Floor Gymnastics' Men v Women **Colab**

. Cleaning, transformation, and visualization of the data were used in variation employing csv reordering, Google Colab, and Power BI. The Average Age of Athletics, Swimming, and overall was rendered using Plotly Express in a variety of charts from line to bar in Google Colab, Fig.9, Fig.10.

```
fig = px.line(averageage,
```

Fig.9

```
fig = px.bar(averageage,
```

Fig.10

The Average Age of Men v Women and Floor Gymnastics Women; age by year were all charted in Power BI tool. It is important to state that with two datasets a relationship between the two needs to be established between the tables in Power BI. Floor Gymnastics Men v Women were graphed comparably by year using Colab *graph_objects*, Fig.11

```
fig = go.Figure()
```

Fig.11

Men's swimming was graphed using Power BI and an overall picture was created in Google Colab by narrowing down the dataset to show only swimming, both men and women, Fig.12, and grouping by year, Fig.13

```
dfnew.query("Sport == 'Swimming'",inplace=True)
```

Fig.12

```
averageage = dfnew.groupby('Year').mean()
```

Fig.13

III. Results and Discussions

A. *Tennis*

The assessment of the changing age profiles in tennis is an interesting one as it would look to provide a conclusion as to the results of the data, it would take another 10 years of data to determine whether the results of this finding are an emerging trend or a fluke phenomenon [14].

From figures in the ATP dataset, it is calculated that the average age of players in 2019 was 27.85 while the average age in 1999 was 25.05.

A very immediate and transparent view of this is evident in graphs of rankings taken from 1999 and 2019 displaying the age ranges, Fig.12 and Fig.13. These show that the age bin in 2019 had increased by a decade since the 1999 rankings.

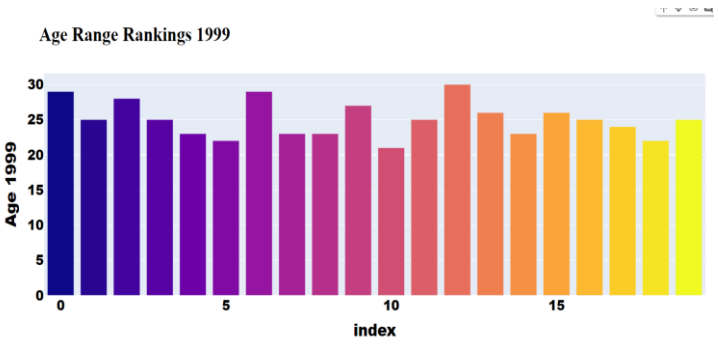

Fig.12

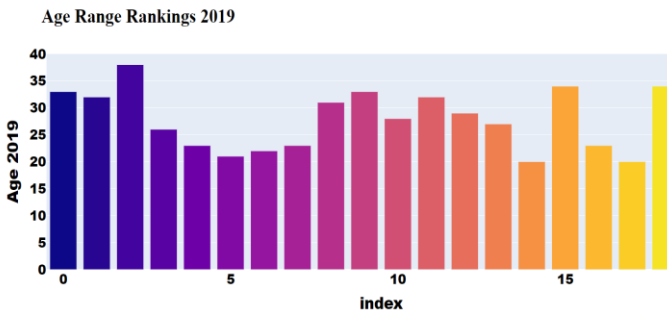

Fig.13

It is always a consideration that the younger players are yet to peak [5], this again would make an interesting observation in revisiting the data in another 10 years. Longevity in this sport would need to be attributed to certain technological, medical, and systematic advances. Even though advances in equipment and field conditions [12] have improved it is no doubt that physiology in tennis players is a main contributing factor in the age-performance ratio of players overall. Fig.14 shows that overall, the age of peak performance is on the whole higher in 2019 than that of 1999

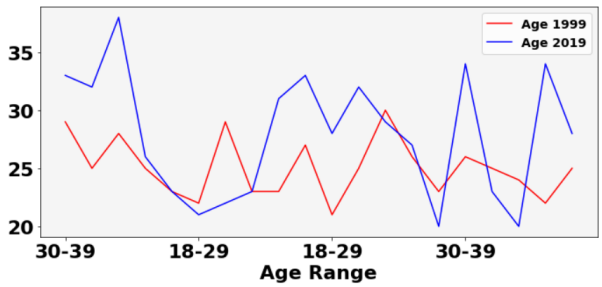

Fig.14

It is also observed that recovery practices have been more of a concentrated method in recent years that inevitably contribute to performance enhancement. Rule changes such as the Masters 1000 mean a player can skip a tournament without financial penalty [5] is one logistical aspect, time being the healer. Other observations are directly related to muscle recovery and overall physiological reboot. These take place in the form of cooling to reduce inflammation, electronic techniques for neuromuscular stimulation, nutrition, rehydration, and hot water immersion for muscle relaxation [15].

B. Rugby

The investigation into peak age in Rugby players was a little less transparent. There are numerous factors to take into account, namely games played, career span, and field position which account for success in that given position. To access this, an in-depth investigation would have to involve various arrangements of measurements for them. Middle forwards generally check out at runs and meters. Edge forwards runs, line breaks, and tackle busts are looked at. While focusing on center and wings, the details are runs, line breaks, and tries, and lastly fullbacks and parts runs and playmaking (line break and try assists) [8].

This type of analysis would be mostly beneficial in terms of recruiting and 'per game' performance analysis, however, an overall look at the career span of rugby players a broader viewpoint has been taken. There have been similar approaches in other studies that snapshot the average age as well as the youngest and eldest, such as Rugbydome in 2022 as shown in Fig.15 and Fig.16 [9]. These provide supportive figures for the results we achieved by looking at the Six Nations figures.

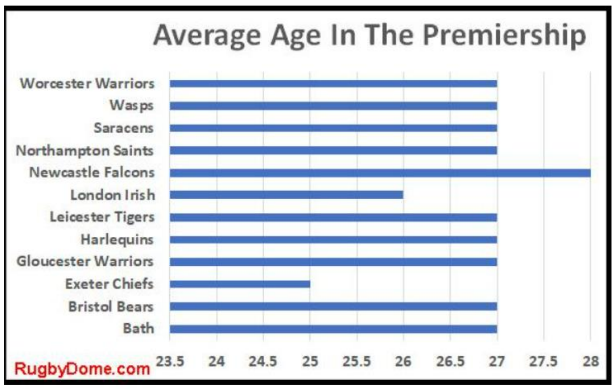

Fig.15

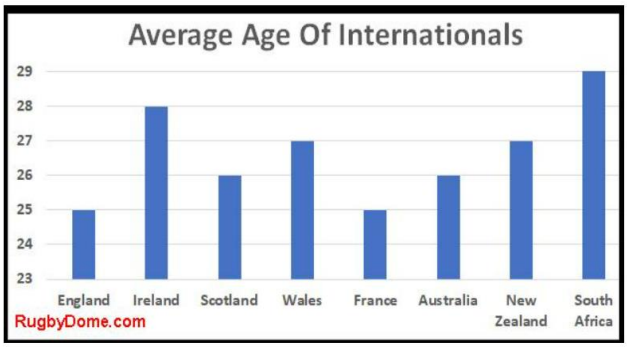

Fig.16

Six Nations figures were 'Player of the Tournament, 2004 to 2019' and 'Top 11 Point Scorers in the Tournament overall'. Fig.17 and Fig.18, which were created from the data, show a uniformity that John Winter derived from looking at Internationals and the English Premiership.

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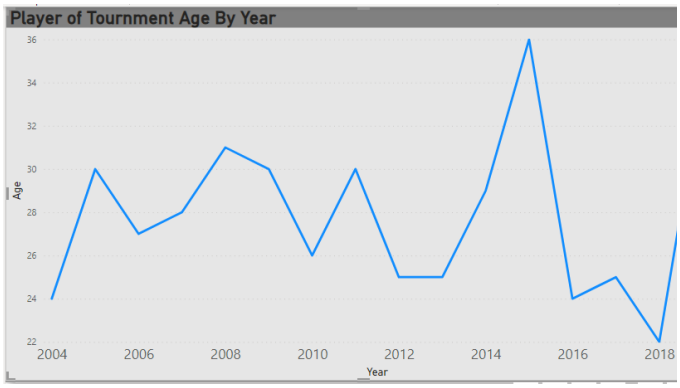

Fig.17

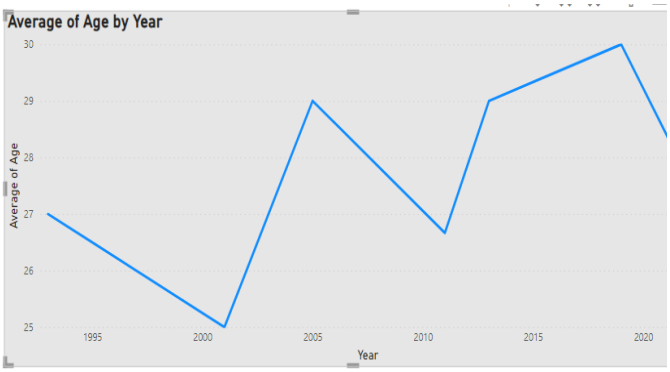

Fig.18

Creating a new measure in Power BI, the average ages of the two categories were established. Namely, the Average age of the Player of the Tournament is 27.88 and the average age of top point scorers is 27.54. This directly aligns with the findings by Winter.

Another aspect that makes rugby different in its modernization is that the body types of players have drastically changed throughout the years. Yet the performance numbers are more or less uniform, unlike other sports across the board. A study taken from Ruck Science showed that the body mass index increased by 24.3% from 1955 to 2015 [3]. This would be a perspective on the sport that would be worth further investigation from the point of view of performance.

C. Olympics

The participants in the Olympics are immense in quantity and unique in skillset, therefore this portion of the study was complex in a different way from the previous two observations. These elite athletes vary from sport to sport. Given the variety of sports, the athletes are utilizing different physical attributes and cognitive abilities. Therefore, ages differ with sports. An example of such is the 2020 Olympics, where 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 [5].

There are arguments however that the age of participants is increasing overall. Like factors discussed with Rugby and Tennis, increased medical, training, and socio-economic factors have contributed to increased participation and benchmarks being surpassed. Fig.19 shows the average age of men and women overall in the Olympics.

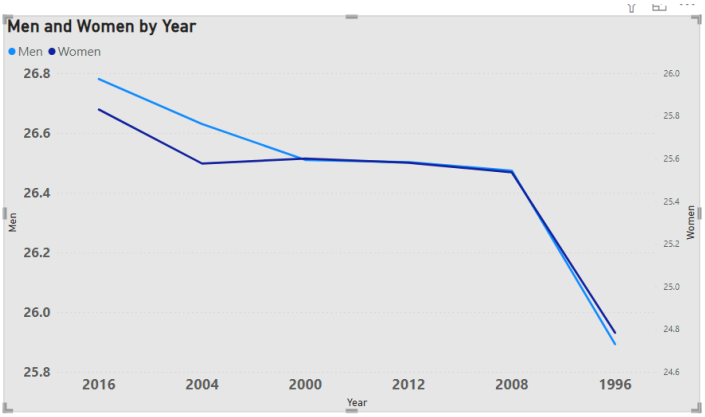

Fig.19

Gymnastics however seems a more complex sport to evaluate in terms of competing age ranges. On initial look at the data, it would appear the age of athletes is increasing more recently at an incremental rate. However, more investigation into the top reveals this study would be necessary to go back further for reference. It seems that the age of gymnasts has been decreasing since the 1950s [16], Fig.20. The highest age of gymnasts was Agnes Keleti-Srkny in 1956 and Zdena Vemiovsk in 1948 at the age of 35, who bold won Gold.

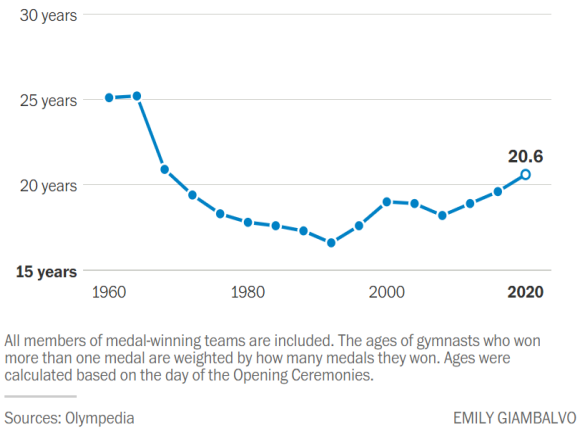

Fig.20

Questioning why the decrease in age occurred seems unique to gymnasts as these competitors are trained at such an early age as the high-risk stunts demand feather-light, pre-pubescent physiques [17]. Gymnastics require a high degree of specialized strength, power, agility, and flexibility, with flexibility being the single greatest discriminator from other sports [18], therefore training at a young age is crucial,

beginning training as early as the age of 4 to 6 year's old [19]. Like Rugby, the correlation between body types and the evolution of the sport and demands itself would be another topic worth examining.

To return to the data taken from recent years, age ranges do appear to creeping back up. In part, it is due to a decision taken in the year 2000 that the minimum age to compete is 16 years old to reduce the toll taken on younger bodies [19]. Some coaches are realizing other benefits from a higher age range, including experience and the ability to harness muscle and power [20]. From the Olympic dataset of average age in athletics overall, this is seen veering away from the early teens, Fig.21.

Fig.21

Examining the Women's floor exercises specifically, there is an obvious trend upward, however marginally, Fig.22, and then in comparison with the men's data, Fig.23.

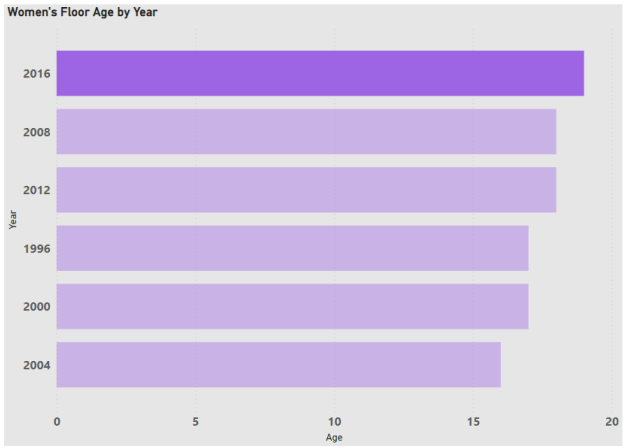

Fig.22

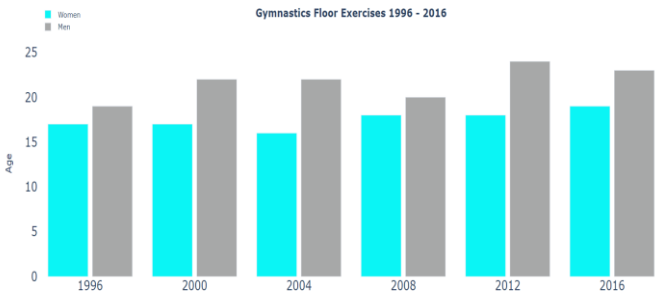

Fig.23

Studies on swimming have encountered similar complexities in terms of measuring output from different events, i.e., 200-meter breaststroke and 800-meter freestyle. However, there was a much more coherent outcome from all events bar that of 200 m backstroke in women, and 400 m freestyle and 200 m breaststroke in men where the age of the finalists decreased [21] from a study of the World Championships (1994–2013) and Olympic Games (1992–2012) [21]. Looking at 200 meters freestyle and 200 meters breaststroke in the men's category shows this tendency, Fig.24

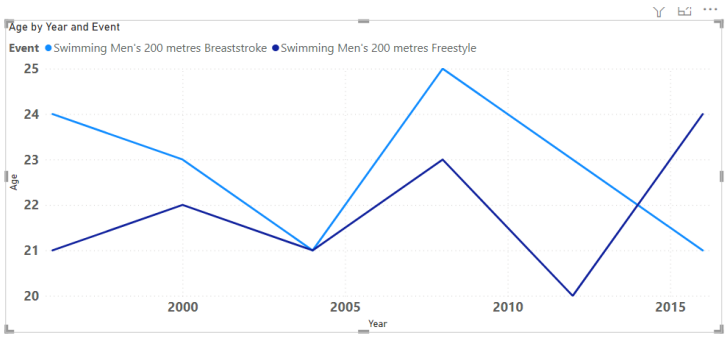

Fig.24

Swimming is generally thought of as a life sport, one the majority of people learn for health and safety reasons, but it only became a competitive sport in the 1830s which is relatively recent in comparison to its sporting counterparts [22]. It is relevant still however that increase height and muscle mass are contributory to the rise in age in world-class swimmers [22] both male and female, Fig.25

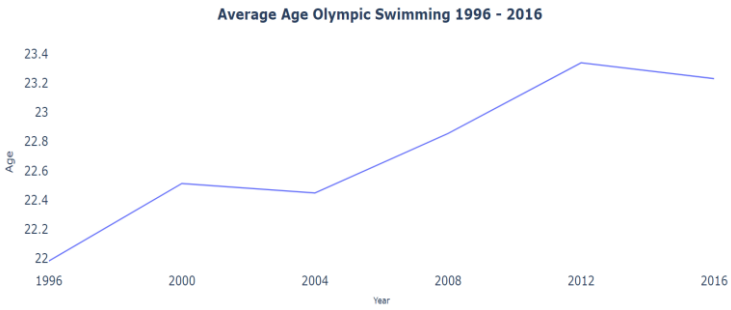

Fig.25

It would be remiss not to mention the highest medal-holding Olympian, Michael Phelps when discussing Tennis.

He has won 28 medals across five Olympics, making him the most decorated athlete in the history of the Summer Games [23] and in Rio 2016, aged 31 just before retirement, he bagged 5 gold medals and 1 silver [24]

Undoubtedly, like all sports, advancements in sociological, economic, technological, and medical factors are contributing to anaerobic energy production, muscle mass, and skills needed to perform at elite levels.

In consideration of the Olympics, it has to be acknowledged that changes in participation leading to increased competition and the fact that Olympians have to earn power through sponsorship and prize money have dramatically affected this longevity in competitors [19] Fig.26 [19]

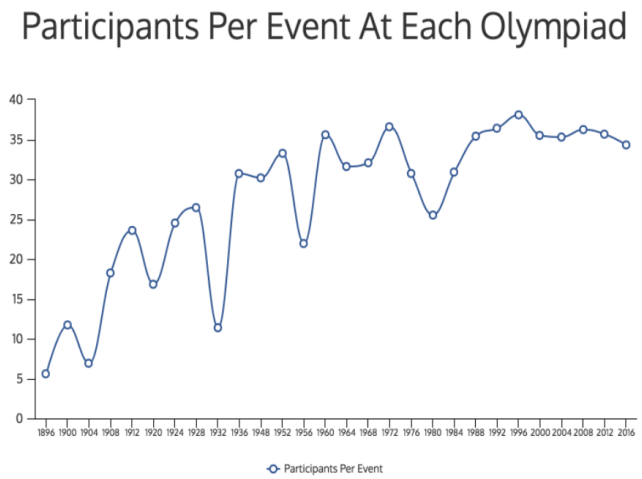

Fig.26

IV. Conclusion

The question about peak age in sporting careers is considerable. This report only took a small example of a few disciplines and it's evident that numerous factors play a part in an athlete's execution of his or her given field. All sports however have several aspects in common through the advancements of technology. Technology has affected how recovery is determined, performance during a match, statistics, training, athletic wear, and physiotherapy. These are however used in varying degrees and different methods specific to each sport. It would be a very interesting viewpoint for future analysis as to how these different technologies are implemented across the board.

Performance however is different in every sport. For the most part, age is increasing but like gymnastics, if not for age limitations to limit damage to younger bodies, the sport would not have adapted to finding achievement in more mature competitors. Rugby also proved a challenging analysis as the game itself requires different skillset depending on the position of any given team member. Performance analysis here is measured more per game than per career.

It is safe to conclude that every discipline is different in its varying demands on the human body and consequently at what age the human body is best equipped to excel in it. Limitations of this study are that a more concentrated analysis of the physical requirements per sport would be needed to would yield a more conclusive result. It's also clear that modern-day resources are better able to facilitate athletes in refining their physical ability and skill to achieve better results.

[1] Dartmouth Sports Analytics, 'Peak Age in Sports', *Dartmouth Sports Analytics*, Nov. 10, 2021. https://sites.dartmouth.edu/sportsanalytics/2021/11/10/peak-age-in-sports/ (accessed Mar. 31, 2022).

[2] C. Breuer, K. Hallmann, P. Wicker, and S. Feiler, 'Socio-economic patterns of sport demand and aging', *Eur Rev Aging Phys Act*, vol. 7, no. 2, Art. no. 2, Sep. 2010, doi: 10.1007/s11556-010-0066-5.

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