Mathematical Modeling Approach to Predict Athletic Time, Performance

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Abstract
As we know that the sporting achievement is always interesting fascinating to human. The major of performance to improve the record and broken as with time, keeping the importance of the subject we have decided to study the problem as suggested by D.Edward & M.Hamson [1]. In this communication we have collected the data for 200m men/ women race athlete time for all three medalists (Gold, silver & bronze) in Olympics from last 60 years i.e. from 1948 to 2008. All the data have been presented in tabular form. It have been observed that the steady fall in winning times for the men’s race indicates that no limiting time for runner at all, which seems unreasonable. We may conclude that the linear model is only valid for a limited range of the years (It may be less than 60 years of the span). Obviously a different model would seem more suitable as $T = a \exp(-b)$. Another important conclusion is that, the more rapid improvement shown in women’s performance could indicates a closing up winning times with the men so that there would be equality between men’s and women’s time near about the year 2090 if performance improvement continued at the same rate.

Keywords
Mathematical Modeling, Modeling of Athlete Time Performance, Mathematical Analysis of Athlete Time

1. Introduction

A mathematical model is a description of a system using mathematical concepts and language of mathematics. Mathematical models are used not only in the natural sciences but now in these days every part of real life situation, a mathematical model can be broadly defined as a formulation or expression of the essential features of a physical or, process in mathematical terms. In the past Indians Babylonians and Greeks indulged in understanding and predicting the natural phenomena through their knowledge of mathematics [1-3]. The architects, artisans and craftsman based on many of their works of art on geometric principles. We can divide the modeling process in to three main process i.e formulation, finding solution and interpretation and evaluation. After building the model we are required to communicate our conclusion as part of solution here in this paper we have studied the real life athletic time problems.

As we know that the sporting achievement is always interesting fascinating to human. The major of performance to improve the record and broken as with time. Now in these days the youth are adopting sports as the carrier also, keeping the importance of the subject we have decided to study the problem as compiled the most recent data as suggested by D.Edward & M.Hamson [1]. In this communication we have presented the data for 200m men/ women race in Olympics from last 60 years i.e. from 1948 to 2008, we have also collected the record for all the three medals i.e. gold, silver and bronze all the data have been presented in tabular form.

2. Problem Description for Athletic Time

It has been observed that in athletics track events winning times are coming down for both man's and women's races. So it was decided to investigate the time achieved for the 200 m by both men and women in the Olympics games. Here with the help of mathematical modeling we wish to investigate/predict the following two queries:

• Is there any limiting time for any human to complete a 100/200/400 m race?

• Will the times of women always be inferior to men?

Data have been collected from the available resources and presented here for the period 1948 to 2008, for the men's and also for women.

3. Formulation of Mathematical Modelling

To formulate the mathematical modeling we are required
the data which is given in the table

3.1 (a) we can observe easily regarding the preponderance of USA winner the times have been decreasing. Although the modern measuring techniques provide the reliable measurement up to the quoted precision. It has been also observed that since 1968 it has been possible to measure correct to the nearest one hundredth of a second. Its practically impossible to imagine what 0.01 sec actually records, but to help we can calculate now for a runner how much will he travel in 0.01 sec.

3.1. Data Representation for Gold Medalists

Following are the data representation for Gold medalists

| YEAR | NAME            | COUNTRY                | TIME (Sec) |
|------|-----------------|------------------------|------------|
| 1948 | Melvin Patton   | United state of America| 21.1       |
| 1952 | Andy Stanfield  | United state of America| 20.7       |
| 1956 | Bobby Morrow    | United state of America| 20.6       |
| 1960 | LiviaBerruti    | Italy                  | 20.5       |
| 1964 | Henry Carr      | United state of America| 20.3       |
| 1968 | Tommy Smith     | United state of America| 19.83      |
| 1972 | Valery Borzov   | Ustawa Republic Solvenje| 20.0       |
| 1976 | Don Quarrie     | Jamaica                | 20.23      |
| 1980 | Pietro Mennea   | Italy                  | 20.19      |
| 1984 | Carl Lewis      | United state of America| 19.80      |
| 1988 | Joe Deloach     | United state of America| 19.75      |
| 1992 | Mike Marsh      | United state of America| 20.01      |
| 1996 | Michael Johnson | United state of America| 19.32      |
| 2000 | Konstantions Kenteris | Greece          | 20.08      |
| 2004 | Shawn Crawford  | United state of America| 19.79      |
| 2008 | Usain Bolt      | Gernica                | 19.3       |

| YEAR | NAME            | COUNTRY                | TIME/s   |
|------|-----------------|------------------------|----------|
| 1948 | Fanny Blankers-Koen | Netherland            | 24.4     |
| 1952 | Marjorie Jackson | Australia              | 23.07    |
| 1956 | Betty Cuthbert   | Australia              | 23.04    |
| 1960 | Wilma Rudolph   | United state of America| 24.00    |
| 1964 | Edith McGuire   | United state of America| 23.00    |
| 1968 | Irena Szewinska | Poland                 | 22.5     |
| 1972 | Renate Stecher  | East Germany           | 22.4     |
| 1976 | Barbal Wockel-Eckert | East Germany      | 20.37    |
| 1980 | Barbal Wockel-Eckert | East Germany      | 22.03    |
| 1984 | Valerie Brisco-Hooks | United state of America| 21.81    |
| 1988 | Florence Griffith –Joyner | United state of America| 21.34    |
| 1992 | Gwen Torrence  | United state of America| 21.81    |
| 1996 | Marie –Jose Perc | France                 | 22.12    |
| 2000 | Pauline Davis Thompson | United state of America| 20.84    |
| 2004 | Veronica Campbell | Germany                | 22.05    |
| 2008 | Veronica Campbell | Germany                | 21.74    |

**Assumptions:**

Running 200m in (say) 20 sec gives an average speed of 10m/s. So the athlete travels 10*0.01m in one hundredth of second = 0.1m =10cm. This is a realistic viewable gap between athletes provide the finish can be photographed. It would seem that a time quoted correct to three place is not realistic.

![Graph for Men V/S Women’s times for 200 m (Gold medalist)](image-url)
3. (A) Mathematical Analysis of 200 M (Gold Medalist)

The shown figure is self explanatory regarding the performances of both men and women athlete for 200 m race. In order to answer the two questions 1 and 2 as described in the section, we have tried to model the patterns of data. And it appears that a downward trend is shown for both men and women as expected. We notice that the performance in both the men's and women's event has slightly deteriorated since 1988 and later the two data sets are very close to each other.

Here We wish to predict that what winning times will be achieved in the future? And how we may compare for both. Looking at the graph in fig 3.1, we have extrapolated forward over the next 20 or 30 years or so and obtain answers to (1) and (2). For the purpose of best fit and prediction we have found the equations: 

\[ y = -0.039x + 101.2 \quad \text{&} \quad R^2 = 0.518 \] for Women’s and 

\[ y = -0.021x + 62.36 \quad \text{&} \quad R^2 = 0.717 \] for men’s.

3.2. Data Representation for Silver Medalists

Following are the data representation for Silver medalists

| YEAR | NAME             | COUNTRY                        | TIME/s |
|------|------------------|--------------------------------|--------|
| 1948 | Barneye bell     | United state of America        | 21.1   |
| 1952 | Thane Baker      | United state of America        | 20.8   |
| 1956 | Andy Stanfield   | United state of America        | 20.7   |
| 1960 | Les Carney       | United state of America        | 20.6   |
| 1964 | Paul Drayton     | United state of America        | 20.05  |
| 1968 | Peter Norman     | Australia                      | 20.00  |
| 1972 | Larryda Black    | United state of America        | 20.19  |
| 1976 | Millard Hampton  | United state of America        | 20.29  |
| 1980 | Allan Wells      | Gesellschaft Burgerlichen Rechets | 20.21  |
| 1984 | Kirk Baptiste    | United state of America        | 19.96  |
| 1988 | Carl Lewis       | United state of America        | 19.79  |
| 1992 | Frankie Fredericks | Non Aligned Movement             | 20.13  |
| 1996 | Frankie Fredericks | Non Aligned Movement             | 19.68  |
| 2000 | Darren Campbell  | Gesellschaft Burgerlichen Rechets | 20.14  |
| 2004 | Bernard Williams | United state of America        | 20.01  |
| 2008 | Shawn Crawford   | United state of America        | 19.96  |

| YEAR | NAME             | COUNTRY                        | TIME/s |
|------|------------------|--------------------------------|--------|
| 1948 | Audrey Willanson | Gesellschaft Burgerlichen Rechets | 25.10  |
| 1952 | Bertha Brouwer   | Netherland                      | 24.20  |
| 1956 | Christa Stubnick | Germany                        | 23.70  |
| 1960 | Jutta Heine      | Germany                        | 24.40  |
| 1964 | Irena Szewinska  | Poland                         | 23.10  |
| 1968 | Raelene Boyle    | Australia                       | 22.70  |
| 1972 | Raelene Boyle    | Australia                       | 22.45  |
| 1976 | Annegret Richter | Federal Republic of Germany     | 22.39  |
| 1980 | Natalya Bolchina | Ustawa Republic Solvenje        | 22.19  |
| 1984 | Florence Griffith-Joynner | United state of America | 22.04  |
| 1988 | Grace Jackson    | Jamiaica                        | 21.72  |
| 1992 | Julit Cuthdert   | Jamiaica                        | 22.02  |
| 1996 | Merlene Ottey-page | Jamiaica                       | 22.24  |
| 2000 | Susanthika Jayasingh | Sri Lanka                      | 22.28  |
| 2004 | Allyson Felix    | United state of America        | 22.18  |
| 2008 | Allyson Felix    | United state of America        | 21.93  |

Figure 3.2. Graph for Men V/S Women’s times for 200 m (Silver medalist)

Mathematical Analysis for 200 M (Silver Medalist)

As per previous case here also downward trend is shown for both men and women as expected. For the purpose of best fit and prediction we have found the equations: 

\[ y = -0.045x + 112.0 \quad R^2 = 0.716 \] for Women’s and 

\[ y = -0.015x + 51.54 \quad R^2 = 0.609 \] for men’s.
3.3. Data Representation for Bronze Medalists

Following are the data representation for Bronze medalists

| YEAR | NAME           | COUNTRY         | TIME/s |
|------|----------------|-----------------|--------|
| 1948 | Lloyd Labeach  | Panama          | 21.2   |
| 1952 | James Gathrs   | United state of America | 20.8   |
| 1956 | Thane Baker    | United state of America | 20.9   |
| 1960 | Abdoulaye Seye | France          | 20.7   |
| 1964 | Edwin Roberts  | Turkmenistan    | 20.6   |
| 1968 | Johan Carlos   | United state of America | 20.00  |
| 1972 | Pietro Mennea  | Italy           | 20.30  |
| 1976 | Dwayne Evans   | United state of America | 20.43  |
| 1980 | Don Quarrie    | Germany         | 20.29  |
| 1984 | Thomas Jefferson | United state of America | 20.26  |
| 1988 | Robson Da Silva | Brazil        | 20.04  |
| 1992 | Michael Bats   | United state of America | 20.38  |
| 1996 | Auto Bolden    | Turkmenistan    | 19.80  |
| 2000 | Auto Bolden    | Turkmenistan    | 20.20  |
| 2004 | Justin Gatlm   | United state of America | 20.03  |
| 2008 | Walter Dix     | United state of America | 19.68  |

| YEAR | NAME           | COUNTRY         | TIME/s |
|------|----------------|-----------------|--------|
| 1948 | Audrey Patterson | United state of America | 25.20 |
| 1952 | Nadezhd Khobykina | Ustawa Republic Solvenje | 24.20 |
| 1956 | Marlene Mathews | Australia     | 23.80 |
| 1960 | Dorthy Hyman   | Gesellschaft Burgerlichen Rechets | 24.70 |
| 1964 | Marilyn Black  | Australia     | 23.10 |
| 1968 | Jenifer Lamy   | Australia     | 22.80 |
| 1972 | Irena Szewinska | Poland        | 22.74 |
| 1976 | Renate Specher | G D R        | 22.74 |
| 1980 | Merlene Ottey-page | Jamiaca     | 22.20 |
| 1984 | Merlene Ottey-page | Jamiaca     | 22.09 |
| 1988 | Heike Drechsler | G D R        | 21.95 |
| 1992 | Merlene Ottey-page | Jamiaca     | 22.09 |
| 1996 | Mary Onyal     | Nigeria       | 22.38 |
| 2000 | Beverly Mcdonald | Jamiaca     | 22.35 |
| 2004 | Debbie Ferguson | Bahrain     | 22.30 |
| 2008 | Kerron Stewart | Jamiaca     | 22.00 |

Mathematical Analysis for 200 M (Bronze Medalist)

As per previous case here also downward trend is shown for both men and women as expected. For the purpose of best fit and prediction we have found the equations: 
\[ y = -0.045x + 112.6 \quad \text{and} \quad R^2 = 0.718 \]
\[ y = -0.018x + 56.86 \quad \text{and} \quad R^2 = 0.733 \]

Figure 3.3. Graph for Men V/S Women’s times for 200 m (Bronze medalist)
4. Result and Discussion of the Problem

The characteristics of the solution in all the above cases are almost same. A downward trend is shown for both men and women as expected. We notice that the performance in both the men's and women's event has slightly deteriorated since 1988. It is also easy to see that two are more data are very close to each other. To return in to the desired prediction as we know the fact that one of the important uses of mathematical modeling is essentially about making reliable and useful predictions. So the issue here is to be predicting from the given data what winning times will be achieved in the future. Looking at the above graphs in each category [Gold, Silver, and Bronze]. We wish to extrapolate forward over the next 40 or 50 years or so and obtain answers to (1) and (2) as desired in the problem description. By looking at the data a simple linear fit for the original raw data have been carried out since neither set suggests clearly any alternative fitting function as shown in the figures for each category [Gold, Silver, and Bronze]. Following conclusion may be made:

- From the above graphs, it is clear that linear models for the 200 m times may be acceptable over the periods covered by the data, what credibility can be placed on times predicted in years ahead? The steady fall in winning times for the men’s race indicates that no limiting time for runner at all which seems unreasonable.

we must conclude that the linear model is only valid for a limited range of the years (It may be less than 50 years of the span) Obviously a different model would seem more suitable as

\[ T = a \exp(-b) \]

Or

\[ T = c + a \exp(-bt) \]

- **For Gold medalists** see [Figure 3.1] If we take Y=0 at x=62.36/0.021=2969. Using the model question first has not been satisfactorily answered so for using the suggested models. With regard to question two, we predict that looking at [Figure (3.1,3.2 & 3.3) ] it is clear that the line for the women’s race is steeper than that for the men. **The more rapid improvement shown in women’s performance could indicates a closing up winning times with the men so that there would be equality between men’s and women’s time near about the year 2090 if performance improvement continued at the same rate.**

- In Gold medalists there would be equality by about the year 2090. In case of Silver medalists there would be equality near about 2060 and for Bronze medal there is equality between men’s and women’s times near about 2070.

- Similar interpretations have been also found in other cases (Silver and Bronze).

Acknowledgements

The authors thank the anonymous referee whose valuable comments and suggestions have helped us to submit the revised version of this manuscript.

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