The Analysis of Running Distances in National Teams in 2010 and 2014 FIFA World Cup and Estimation of Oxygen Consumption Capacity Based on These Distances

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Abstract
This study aims to analyze running distances in national teams during 2010 and 2014 FIFA World Cup and to propose a new program which estimates oxygen consumption capacity based on running distances. The data were evaluated by SPSS 22.0 statistical package program. The findings demonstrate that among teams participating in 2010 and 2014 FIFA World Cup, the lowest average running distance and estimated VO$_2$max values belong to Brazil with 7398.77 meters and 43.84 ml/kg/m, respectively. On the other hand, the highest average running distance and estimated VO$_2$max values belong to Australia with 10598 meters and 67.69 ml/kg/m, respectively. The average running distance and estimated VO$_2$max value in national teams participating in 2010 FIFA World Cup was 9635.54 meters and 60.52 ml/kg/m, while they were 9095.82 meters and 52 ml/kg/m in 2014 FIFA World Cup, respectively.

Keywords: FIFA World Cup 2010-2014, running distances, VO$_2$max

1. Introduction
Historical developments and natural conditions (pitch conditions, cultural values and physical features) lead to the emergence of different playing styles in different regions and countries of the world. There are different schools in various countries of the world, and each school brings a new taste to football. For instance, English football attaches importance to running, physical tackling, long passes and a high tempo until the end of 90 minutes. Brazilian football seems to have reached the highest elegance on the pitch. On the other hand, German and Dutch football is based on a more detailed technical game plan, and requires long running distances (Wahl, 2005).

The energy spent during a football game requires players to possess some physiological capacities, which are directly associated with player’s physical condition and training methods. Football requires different approaches depending on the playing style, position on the pitch and difficulty level of the match. All players need to possess the ball during the game, and become fast and active in order to support their teammates for defending and attacking. They are often expected to run for 90 minutes and support the teammate possessing the ball in a suitable position on the pitch (Reilly, 2003).

2. Methods
The average running distances during the tournament were used to estimate running distance in these national teams. (M-0.3138)/0.0.278 formula, which was developed by Cooper (Cooper, 1968) was used to estimate approximate VO2max values of the teams. The numbers in this formula (1), which enables to estimate VO2max values during 12 minutes, were multiplied by 3 in order to estimate VO2max values for 36 minutes. In a football match, during a half of 45 minutes, nearly 9 minutes are spent passively (penalty kick, free kick, goal kick, fouls etc.). Thanks to our modified formula, a new VO2max formula was developed in order to approximately estimate running distances in a football match. As a result, oxygen consumption of the players in a team was estimated based on their running distances.

\[ \text{VO}_2\text{max} = \frac{\text{Running Distance} - 0.9414}{0.0834} \]  
(1)

[Running Distance/1 mile (1.609m)]

Direct VO$_2$max estimation may pose threats to a player’s life because it needs to be measured on his respiratory, circulatory and heart system. In fact, it is compulsory to maintain a medical staff during a VO$_2$max measurement. Nevertheless, as mentioned above, methods for VO$_2$max measurement have not been developed yet. These estimations usually yield results similar to direct VO$_2$max measurements. However, these methods are called “sub-maximal
measurements” because circulatory and respiratory systems are not fully activated.

2.1 VO\textsubscript{2max} Test

The average running distances during the tournament were used to estimate running distance in these national teams. (M-0.3138)/0.278 formula, which was developed by Cooper (Cooper, 1968).

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2.2 Statistical Analyses

After the data were analyzed through the SPSS 22 software program, descriptives statictics analysis was used to the analysis of running distances in national teams in 2010 and 2014 FIFA World Cup and estimation of oxygen consumption capacity based on these distances.

3. Findings

Table 1. Average running distances and VO\textsubscript{2max} values in national teams participating in 2010 and 2014 FIFA World Cup

| Teams      | N | Distance (m) | 2010 VO\textsubscript{2} (ml / kg / min) | Distance (m) | 2014 VO\textsubscript{2} (ml / kg / min) |
|------------|---|--------------|------------------------------------------|--------------|------------------------------------------|
| Australia  | 2 | 10598.0      | 67.69                                    | 9775.3       | 61.56                                    |
| Swiss      | 2 | 10342.0      | 65.78                                    | 9349.8       | 58.39                                    |
| Portugal   | 2 | 10160.2      | 64.43                                    | 9103.3       | 56.55                                    |
| Mexico     | 2 | 10093.7      | 63.93                                    | 9213.75      | 57.37                                    |
| Germany    | 2 | 10061.8      | 63.69                                    | 9855.66      | 62.16                                    |
| Serbia     | 1 | 10014.0      | 63.34                                    |              |                                          |
| South Africa | 1 | 9957.3       | 62.92                                    |              |                                          |
| America    | 2 | 9946.15      | 62.83                                    | 9996.0       | 63.20                                    |
| Italy      | 2 | 9926.1       | 62.68                                    | 8924.6       | 55.22                                    |
| Japan      | 2 | 9887.06      | 62.39                                    | 9143.0       | 56.85                                    |
| South Korea | 2 | 9860.5       | 62.19                                    | 9404.6       | 58.80                                    |
| Britain    | 2 | 9856.7       | 62.17                                    | 9076.0       | 56.35                                    |
| Slovakia   | 1 | 9755.7       | 61.41                                    |              |                                          |
| North Korea| 1 | 9753.6       | 61.40                                    |              |                                          |
| Slovenia   | 1 | 9707.6       | 61.05                                    |              |                                          |
| Uruguay    | 2 | 9636.15      | 60.52                                    | 8848.25      | 54.65                                    |
| Chile      | 2 | 9559.25      | 59.95                                    | 9439.7       | 59.06                                    |
| Spain      | 2 | 9531.65      | 59.74                                    | 9212.0       | 57.36                                    |
| Algeria    | 2 | 9519.66      | 59.65                                    | 9385.2       | 58.65                                    |
| Denmark    | 1 | 9496.6       | 59.48                                    |              |                                          |
| Paraguay   | 1 | 9483.11      | 59.38                                    |              |                                          |
| Greece     | 2 | 9423.33      | 58.94                                    | 8462.1       | 51.77                                    |
| Netherlands| 2 | 9411.73      | 58.85                                    | 9360.96      | 58.47                                    |
| France     | 2 | 9366.66      | 58.51                                    | 9091.8       | 56.47                                    |
| New Zealand| 1 | 9333.0       | 58.26                                    |              |                                          |
| Cameroon   | 2 | 9321.33      | 58.18                                    | 8476.3       | 51.88                                    |
| Ivory      | 2 | 9283.66      | 57.89                                    | 8271.6       | 50.35                                    |
| Ghana      | 2 | 9268.37      | 57.78                                    | 9408.3       | 58.82                                    |
| Brazil     | 2 | 9107.0       | 56.58                                    | 7398.77      | 43.85                                    |
| Honduras   | 2 | 9092.0       | 56.47                                    | 8117.3       | 49.20                                    |
| Argentina  | 2 | 8976.4       | 55.61                                    | 8818.64      | 54.43                                    |
| Nigeria    | 2 | 8606.66      | 52.85                                    | 8862.5       | 54.76                                    |
| Costa Rica | 1 | -            | -                                        | 8920.3       | 55.19                                    |
| Belgium    | 1 | -            | -                                        | 9205.2       | 57.31                                    |
| Colombia  | 1 | -            | -                                        | 8851.6       | 54.68                                    |
| Croatia    | 1 | -            | -                                        | 9097.3       | 56.51                                    |
| Equator    | 1 | -            | -                                        | 8929.6       | 55.26                                    |
| Iran       | 1 | -            | -                                        | 9497.6       | 59.49                                    |
| Bosnia     | 1 | -            | -                                        | 9526.0       | 59.70                                    |
| Russia     | 1 | -            | -                                        | 10043.3      | 63.56                                    |
| Team averages and VO\textsubscript{2max} values | | 9635.54 | 60.52 | 9095.82 | 56.50 |
Average Running Distances in National Teams Participating in 2010 FIFA World Cup 9635.54 meters.

Average Running Distances in National Teams Participating in 2014 FIFA World Cup 9095.82 meters.

Graph 1. Average Running Distances in National Teams Participating in 2010 and 2014 FIFA World Cup

Table 2. Average running distances in national teams participating in 2010 and 2014 FIFA World Cup and standard deviation of their success

| Row | Teams     | N  | 2010 Average Running Distance | 2010 Success | 2014 Average Running Distance | 2014 Success | 2010-2014 xsd |
|-----|-----------|----|-------------------------------|--------------|-------------------------------|--------------|---------------|
| 1   | Spain     | 2  | 9531.65                       | Winner       | 9212                          | Group Stage  | 9371.83±22.03 |
| 2   | Netherlands| 2  | 9411.73                       | Runner-up    | 9360.96                      | Third Place  | 9386.35±35.90 |
| 3   | Germany   | 2  | 10081.86                      | Third Place  | 9855.56                      | Winner       | 9936.76±145.81 |
| 4   | Uruguay   | 2  | 9636.15                       | Fourth Place | 8848.25                      | Round of 16  | 9247.70±28.13 |
| 5   | Argentina | 2  | 8976.4                        | Quarter Final| 8818.64                      | Runner-up    | 8897.52±111.55 |
| 6   | Ghana     | 2  | 9268.37                       | Quarter Final| 9408.3                        | Group Stage  | 9338.34±98.95 |
| 7   | Paraguay  | 1  | 9483.11                       | Quarter Final| -               | -             | 9483.11       |
| 8   | Brazil    | 2  | 9107                          | Quarter Final| 7398.77                      | Fourth Place | 8252.89±207.90 |
| 9   | America   | 2  | 9946.18                       | Round of 16  | 9996                          | Round of 16  | 9971.09±35.23 |
| 10  | Japan     | 2  | 9887.06                       | Round of 16  | 9143                          | Group Stage  | 9515.03±52.13 |
| 11  | South Korea| 2  | 9860.5                        | Round of 16  | 9404.6                        | Group Stage  | 9632.52±222.37 |
| 12  | Mexico    | 2  | 10093.75                      | Round of 16  | 9213.75                      | Round of 16  | 9653.75±222.25 |
| 13  | Chile     | 2  | 9559.25                       | Round of 16  | 9439.7                        | Round of 16  | 9499.48±84.53 |
| 14  | Slovakia  | 1  | 9755.75                       | Round of 16  | -                             | -             | 9755.75       |
| 15  | Portugal  | 2  | 10160                        | Round of 16  | 9103.3                        | Group Stage  | 9631.63±47.20 |
| 16  | Britain   | 2  | 9856.75                       | Round of 16  | 9076                          | Round of 16  | 9466.38±52.07 |
| 17  | France    | 2  | 9366.67                       | Group Stage  | 9091.8                       | Quarter Final| 9229.23±194.36 |
| 18  | South Africa| 1  | 9957.33                      | Group Stage  | -                             | -             | 9957.33       |
| 19  | Nigeria   | 2  | 8606.667                      | Group Stage  | 8862.25                      | Round of 16  | 8734.58±180.90 |
| 20  | Greece    | 2  | 9423.333                      | Group Stage  | 8462.1                        | Round of 16  | 8942.72±67.69 |
| 21  | Slovenia  | 1  | 9707.667                      | Group Stage  | -                             | -             | 9707.66       |
| 22  | Algeria   | 2  | 9519.667                      | Group Stage  | 9385.2                        | Round of 16  | 9452.43±95.08 |
| 23  | Australia | 2  | 10598                         | Group Stage  | 9775.3                        | Group Stage  | 10186.63±581.74 |
| 24  | Serbia    | 1  | 10014                         | Group Stage  | -                             | -             | 10014.00      |
| 25  | Denmark   | 1  | 9496.667                      | Group Stage  | -                             | -             | 9496.67       |
| 26  | Cameroon  | 2  | 9321.333                      | Group Stage  | 8476.3                        | Group Stage  | 8898.82±397.53 |
| 27  | Italy     | 2  | 9926                          | Group Stage  | 8924.6                        | Group Stage  | 9427.30±108.10 |
| 28  | New Zealand| 1  | 9333                         | Group Stage  | -                             | -             | 9333.00       |
| 29  | Ivory     | 2  | 9283.667                      | Group Stage  | 8271.6                        | Group Stage  | 8777.63±715.64 |
| 30  | North Korea| 1  | 9753.667                      | Group Stage  | -                             | -             | 9753.67       |
| 31  | Honduras  | 2  | 9092                          | Group Stage  | 8117.3                        | Group Stage  | 8604.65±689.22 |
| 32  | Swiss     | 2  | 10342                         | Group Stage  | 9349.8                        | Round of 16  | 9845.90±701.59 |
| 33  | Costa Rica| 1  | -                            | Group Stage  | 8942.3                        | Quarter Final| 9200.30       |
| 34  | Belgium   | 1  | -                            | Group Stage  | 8925.2                        | Quarter Final| 9205.20       |
| 35  | Colombia  | 1  | -                            | Group Stage  | 8851.6                        | Quarter Final| 8851.60       |
| 36  | Croatia   | 1  | -                            | Group Stage  | 9097.3                        | Group Stage  | 9097.30       |
| 37  | Equator   | 1  | -                            | Group Stage  | 8929.6                        | Group Stage  | 8929.60       |
| 38  | Iran      | 1  | -                            | Group Stage  | 9497.6                        | Group Stage  | 9497.60       |
| 39  | Bosnia    | 1  | -                            | Group Stage  | 9526                          | Group Stage  | 9526.00       |
| 40  | Russia    | 1  | -                            | Group Stage  | 10043.3                       | Group Stage  | 10043.30      |
Table 3. Minimal and maximal running distances in national teams participating in 2010 and 2014 FIFA World Cup

| Teams         | N | Minimum | Maximum | x±sd |
|---------------|---|---------|---------|------|
| Australia     | 2 | 9775.30 | 10598.00| 10186.65 | 581.74 |
| Russia        | 1 | 10043.30| 10043.30| 10043.30 |
| Serbia        | 2 | 10014.00| 10014.00| 10014.00 |
| America       | 2 | 9946.18 | 9996.00 | 9971.09 | 35.23 |
| Germany       | 2 | 9855.66 | 10061.86| 9958.76 | 145.81 |
| South Africa  | 1 | 9957.33 | 9957.33 | 9957.33 |
| Switzerland   | 2 | 9349.80 | 10342.00| 9845.90 | 701.59 |
| Slovakia      | 1 | 9755.75 | 9755.75 | 9755.75 |
| North Korea   | 1 | 9753.67 | 9753.67 | 9753.67 |
| Slovenia      | 1 | 9707.67 | 9707.67 | 9707.67 |
| Mexico        | 2 | 9213.75 | 10093.75| 9653.75 | 622.25 |
| South Korea   | 2 | 9404.60 | 9860.50 | 9632.55 | 322.37 |
| Portugal      | 2 | 9103.30 | 10160.00| 9631.65 | 747.20 |
| Bosnia        | 1 | 9526.00 | 9526.00 | 9526.00 |
| Japan         | 2 | 9143.00 | 9887.06 | 9515.03 | 526.13 |
| Chile         | 2 | 9439.70 | 9559.25 | 9499.48 | 84.53 |
| Iran          | 1 | 9497.60 | 9497.60 | 9497.60 |
| Denmark       | 1 | 9496.67 | 9496.67 | 9496.67 |
| Paraguay      | 1 | 9483.11 | 9483.11 | 9483.11 |
| Britain       | 2 | 9076.00 | 9856.75 | 9466.38 | 552.07 |
| Algeria       | 2 | 9385.20 | 9519.67 | 9452.43 | 95.08 |
| Italy         | 2 | 8924.60 | 9926.00 | 9425.30 | 708.10 |
| Netherland    | 2 | 9360.96 | 9411.73 | 9386.35 | 35.90 |
| Spain         | 2 | 9212.00 | 9531.65 | 9371.83 | 226.03 |
| Ghana         | 2 | 9268.37 | 9408.30 | 9338.34 | 98.95 |
| New Zealand   | 1 | 9333.00 | 9333.00 | 9333.00 |
| Uruguay       | 2 | 8848.25 | 9636.15 | 9242.20 | 557.13 |
| France        | 2 | 9091.80 | 9366.67 | 9229.23 | 194.36 |
| Belgium       | 1 | 9205.20 | 9205.20 | 9205.20 |
| Croatia       | 1 | 9097.30 | 9097.30 | 9097.30 |
| Greece        | 2 | 8462.10 | 9423.33 | 8942.72 | 679.69 |
| Equator       | 1 | 8929.60 | 8929.60 | 8929.60 |
| Costa Rica    | 1 | 8920.30 | 8920.30 | 8920.30 |
| Cameroon      | 2 | 8476.30 | 9321.33 | 8898.82 | 597.53 |
| Argentina     | 2 | 8818.64 | 8976.40 | 8897.52 | 111.55 |
| Colombia      | 1 | 8851.60 | 8851.60 | 8851.60 |
| Ivory         | 2 | 8271.60 | 9283.67 | 8777.63 | 715.64 |
| Nigeria       | 2 | 8606.67 | 8862.50 | 8734.58 | 180.90 |
| Honduras      | 2 | 8117.30 | 9092.00 | 8604.65 | 689.22 |
| Brazil        | 2 | 7398.77 | 9107.00 | 8252.89 | 1207.90 |

4. Discussion

It can be observed that a player’s running distance has increased in the last ten years. For instance, average running distance is nearly 11,000 meters in 90 minutes. Because players playing in different positions on the pitch perform different duties, midfielders’, defenders’ and forwards’ running distances are estimated to be 11.4, 10.1 and 10.5 kilometers, respectively. It can be stated that a player’s running distance during a football match varies between 8 and 11 kilometers. A football player performs different activities during a match such as standing (17.01%), walking (40.4%), low tempo running (35.1%), high tempo running (8.1%), high tempo sprint (0.7), as well as other activities such as tackling, headers and shooting, dribbling, and jumping (Günay, & Yüce, 1996). The close proximity of football players with an average MaxVO₂ values of 55-65 ml/kg/min to long distance runners underlines the importance of the aerobic energy spent by these players (Marangoz, & Gençay, 2017).

When VO₂max measurements of football teams are analyzed, Yamaner (1987) reports that VO₂max of 15 players in Gençlerbirliği was measured as 54.58 ml/kg/min. İşlegen (1987) stated that VO₂max value of 19 players in Turkish First Football League, 12 players in Turkish Second Football League and 18 players in Turkish Third Football League as 51.55 ml/kg/min, 51.17 ml/kg/min and 48.09 ml/kg/min, respectively. Yamaner (1990) found out that VO₂max value of 17 players in Galatasaray was 59.35 ml/kg/min. Mümüroğlu et al. (2000) reports that VO₂max of 20 players in Turkish First Football League was measured as 59.48 ml/kg/min. Koç et al. (2000) observed that VO₂max value of 18 players in Kütahyaspor, a football team in Turkish Third Football League, was 54.71 ml/kg/min. In a study on 63 football players in Turkish First, Second and Third Football League, Kızılet et al. (2002) measured VO₂max as 54.34
ml/kg/min. Simrkavak et al. (2004) reports that VO₂max value of 10 players in Sivasspor was calculated as 42.84 ml/kg/min. Marangoz & Gençay (2017) demonstrated that VO₂max values of two groups of 24 players in Kahramanmaraşspor and Siirtspor were measured as 57.62±3.25 ml/kg/min and 59.45±4.46ml/kg/min, respectively.

Reeves et al. (1999) measured VO₂max values of 18 players in English Premier League and 14 players in Hong Kong as 50.0 ml/kg/min and 59.1 ml/kg/min, respectively. Ostojić (2000) reports that VO₂max values of two groups of 16 players in Serbian First and Third Football League was measured as 53.5 ml/kg/min and 42.9 ml/kg/min, respectively. Edwards et al. (2003) found out that VO₂max value of 20 players in English Premier League was 62.1 ml/kg/min. In a study on 20 elite football players in Irish League, McIntyre (2005) observed that VO₂max was calculated as 57.6 ml/kg/min. In a study on 72 football players in Japan, Tahara et al. (2006) reported VO₂max as 54.0 ml/kg/dk.

Although the highest VO₂max value measured in studies on football players is 80 ml/kg/min, this value is nearly 55-68 ml/kg/min for male football players except goalkeepers. It can be observed that VO₂max values measured in recent years have varied between 61.1 and 70.7 ml/kg/min in recent years (Aşçı, 2003).

5. Conclusion
In conclusion, the modified formula developed for this study to estimate oxygen consumption capacity measured VO₂max levels of national teams participating in 2010 and 2014 FIFA World Cup as 60.52 ml/kg/min and 56.50 ml/kg/min, respectively. It can be argued that these values are lower than VO₂max values measured in recent years. It was also demonstrated that average running distances of national teams participating in 2010 and 2014 FIFA World Cup were nearly 9500 meters, which is lower than the running distances measure in recent years. Finally, no significance or correlation was observed between running distance and success in the tournament.

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