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27 Years Women Participants' Trends in the Olympic Movement and Future Directions

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ABSTRACT

Sports and games are the most powerful platforms for raising gender equality and empowering girls and women. The current report examines the women participants' trends in the Olympic movement from 1900 to 2016. Women participants' trends equation has been derived herein based on statistical modeling. It is derived herein that the percentage of women participants is directly associated with the number of women events (P<0.0001), implying that women participants increase as the number of women events increases. The derived mean trend equation is in a second degree of the transformed time 't', while its variance is linear in time 't'. The report concludes that the increase rate of women participants is very low from 1900 to 1924, and it is almost stable from 1945 to 1975, and it increases from 1980, but it is almost stable from 2000 to 2016. The women participants' trends are not quite satisfactory, and extra care should be taken in future.

INTRODUCTION:

An international sports festival is the Olympic games, which were started in ancient Greece. The main Greek games were performed every fourth year for several hundred years until they were abolished in the early Christian era. The renewal of the Olympic games began in 1896, and since then they have been performed every fourth year, except during World War I (1916), World War II (1940, 1944), and the Covid-19 pandemic (2020). Probably the main difference between the ancient and present Olympic is that the previous was the ancient Greeks' way of worshipping their Gods, while the present games are a way of worshipping the athletic talents of citizens of all nations. The main Olympic shaped competition in oratory, music, and theater performances as well, while the present games have a more extensive athletic agenda, and for two and a half weeks they are supposed to replace the animosity of international conflict with friendly competition. In present times, however, that proud ideal has not always been attained.

Over the world, the largest multisport event is the Olympic games, which draw a regular global audience in the billions to observe coverage of athletes from more than hundreds of nations. It has attracted a great deal of scholarly attention, particularly in terms of consumption, media coverage, and co-creation. Since the inception of the modern, or present Olympic games in 1896, they have grown to become the largest multisport event over the world. It is well-recorded in the literature of the Olympic game that coverage of the has games the power to impact entire nations and cultures, and so the study of such media is important. For instance, Eagleman *et al.* (2014) illustrated that media coverage plays a large role in crafting the fact of the Olympic games for those who cannot attend and experience it firsthand. It covered a deep impact on citizens' views of topics such as nationality, gender, and the perceived importance of some sports over others (Eagleman *et al.* 2014; p. 457). A systematic Olympic games literature review over a 20-year time period (1999–2018) was conducted to examine the state of Olympic media research by Geurin and Naraine (2020). The review report by Geurin and Naraine (2020) covers around 221 articles, and it illustrates the types of research related to the Olympic games from methodological, theoretical, and contextual perspectives. Readers may go through the following the most important articles related to Olympic games by Irwin and Ryan (2013); International Olympic Committee (IOC) (2019); Houlihan *et al.* (2017); Fink (2019); Filo *et al.* (2015).

Women first took part in the Olympic games in Paris in 1900. The IOC (2018, 2019) has illustrated the women's participation status using some statistical diagrams such as bar diagrams, pie diagrams, etc. Best of our knowledge, there is no study of women participants' trends through statistical trend equations. The long time variation of a time series data for smooth downward decrease, or upward increase is recognized as a trend, which is neatly illustrated in the books by Montgomery *et al.* (2016); Shumway and Stoffer, (2017). The above books illustrate only the mean trend with constant variance, which is not true always. It is well-noted that variance has its own interpretations. For heteroscedastic data, both mean and dispersion equations can be considered jointly using joint generalized linear models (JGLMs) (Lee *et al.* 2017). The current report aims to study the women participants' trends from 1990 to 2016 using appropriate statistical trends equations. The present report is ordered as follows. The following section reveals the materials & methods, and the subsequent sections present respectively statistical analysis & results, discussion and conclusion.

MATERIALS AND METHODS:

MATERIALS:

The IOC (2018) provides the Olympic games data on the website. The report considers only the percentage of women participants trends in the Olympic games from 1900 to 2016, so it includes Olympic games data related to women. It considers the Olympic games data on the year, sports, number of women events, the total number of events, percentage of women events, women participants, percentage of women participants. For ready reference, women-related Olympic games data is given in the Appendix.

METHODS:

Statistical methods

The response percentage of women participants in the Olympic games is heteroscedastic, positive and continuous, which can be modeled using the transformation of data by stabilizing variance. But in many cases, the variance is not stabilized using transformation (Myers *et al.* 2002). Commonly, a positive continuous homogeneous random variable is modeled either by a gamma, or lognormal model (Firth, 1988). But for an unequal variance random response variable modeling, JGLMs under lognormal, or gamma distributions can be applied (Lee *et al.* 2017; Das and Lee 2009). JGLMs is explicitly described in the book by Lee *et al.* (2017). The present data on the percentage of women participants' is well fitted by the JGLMs under gamma distribution, which is very shortly reproduced in the following herein.

JGL Gamma Models: Here the percentage of women participants in the Olympic games = y_i say, is the interesting study continuous & positive response random dependent variable with unequal variance (σ_i^2), and mean $\mu_i = E(y_i)$, satisfying $Var(y_i) = \sigma_i^2 \mu_i^2 = \sigma_i^2 V(\mu_i)$ say, where *V*(.) is recognized as variance function, and the variance contains two portions such that σ_i^2 (free of mean changes) and $V(\mu_i)$ (depends on the mean changes). Note that $V(\cdot)$ identifies the GLM family distribution as if $V(\mu)=\mu$, it is Poisson, and it is Normal, or gamma according as $V(\mu)= 1$, or $V(\mu) = \mu^2$, etc. Mean & dispersion JGLMs for the percentage of women participants in the Olympic games under gamma distribution are presented by:

$$\eta_i = g(\mu_i) = x_i^t \beta \text{ and } \varepsilon_i = h(\sigma_i^2) = w_i^t \gamma,$$

where $g(\cdot)$ & $h(\cdot)$ are the GLM link, or connected functions related with the mean & dispersion linear predictors respectively, and x_i^t, w_i^t are the vectors of explanatory variables, related with the mean and dispersion parameters respectively. Maximum likelihood (ML) method is used to estimate mean parameters, while the restricted ML (REML) method is used to estimate dispersion parameters (Lee *et al.* 2017).

RESULTS AND DISCUSSION:

STATISTICAL RESULTS AND GRAPHICAL DIAGNOSIS

Statistical results

The dependent variable percentage of women participants in the Olympic games is modeled on the percentage of women events and the transformed time t= (Year-1964)/4 using JGLMs under the gamma distribution. Here are the percentage of women events and the transformed time 't' are treated as independent variables, while the percentage of women participants in the Olympic games is treated as the response random variable, which is heteroscedastic. The best JGLM has been accepted based on the lowest Akaike Information Criterion (AIC) value (within each class) that minimizes both the predicted additive errors and squared error loss (Hastie *et al.* 2009, p. 203-204). The final percentage of women participants in the Olympic games gamma JGLMs analysis results are shown in Table 1.

Table No. 1: Final joint gamma model fitting of a percentage of women participants' (y_2) in the Olympic Games

Model	Covariate	Estimate	Standard error	t-value	P-value
Mean	Constant	1.4627	0.09199	15.901	<0.0001
	% of women events (y1)	0.0599	0.00473	12.663	<0.0001
	T	0.0229	0.00995	2.302	0.0307
	t^2	-0.0047	0.00057	-8.235	<0.0001
Dispersion	Constant	-3.951	0.2950	-13.392	<0.0001
	T	-0.204	0.0365	-5.586	<0.0001
AIC		**97.388**			

In Table 1, it is obtained that percentage of women participants in the Olympic games is unequal variance random response variable, and its mean, or average is positively associated with the percentage of women events (y1) (P<0.0001) and the transformed time t (P=0.0307), while it is negatively associated with t^2 (P<0.0001). Its variance is negatively associated with t (P<0.0001).

Final gamma fitted percentage of women participants in the Olympic games mean ($\hat{\mu}$) model (Table 1) is

$$\hat{\mu} = \exp.(1.4627 + 0.0599y1 + 0.0229\, t - 0.0047\, t^2),$$

and the final gamma fitted percentage of women participants' in the Olympic games dispersion ($\hat{\sigma}^2$) model is

$$\hat{\sigma}^2 = \exp.(-3.951 - 0.204\ t).$$

Graphical diagnosis

The developed JGL gamma fitted percentage of women participants in the Olympic games (Table 1) probabilistic model is a data developed model, which is examined adopting model diagnostic plots in Figure 1. Figure 1(a) presents the absolute residuals plot for the gamma fitted percentage of women participants in the Olympic games against the fitted values that is a flat straight line, concluding that variance is constant with the running means. Figure 1(b) presents the normal probability plot for the gamma fitted percentage of women participants in the Olympic games mean model (Table 1) that does not show any fit discrepancy. Thus, Figure 1 shows that the fitted percentage of women participants in the Olympic games model (Table 1) is close to its unknown true model.

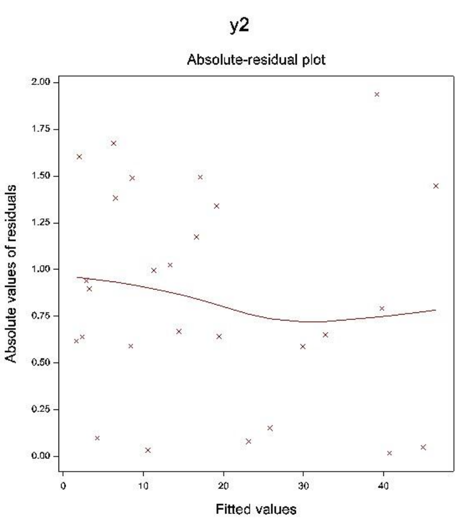

Figure 1(a)

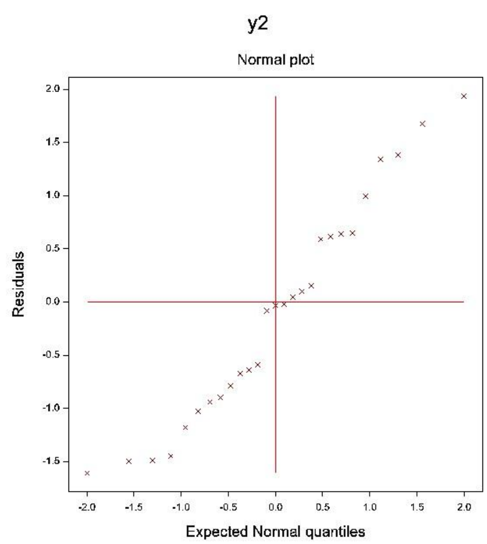

Figure 1(b)

Figure No. 1: For the joint gamma fitted percentage of women participants' models (y2) (Table 1), the (a) absolute residuals plot against the fitted values, and (b) the normal probability plot for the mean y2 model.

CONCLUSION:

The Olympic Games data set is a multivariate form, and the response percentage of women participants’ is heteroscedastic, positive, and continuous which is modeled by JGLMs. Best of our knowledge, JGLMs of the percentage of women participants' on time ‘t’ and the percentage of women events are not studied in any earlier reports. The derived models are examined by graphical analysis. The obtained regression coefficient estimates of the percentage of women participants’ fitting (Table 1) have the lower standard error, interpreting that estimates are stable. The final accepted JGLMs of the percentage of women participants’ (Table 1) have been taken based on the smallest AIC value, graphical diagnosis, and smaller standard errors of the estimates. One can examine the reported results in the article using the data set given in the Appendix. Best of our knowledge, the derived gamma fitted JGLMs of the percentage of women participants’ (in Table 1) are very close to their true models.

In Table 1, it is obtained that the percentage of women participants in the Olympic games is unequal variance random response variable, and it's mean, or average is positively associated with the percentage of women events (y1) ($P<0.0001$), concluding that the percentage of women participants’ increases as the percentage of women events increases. It is true in practice. Note that mean is positively associated with the transformed time t ($P=0.0307$), while it is negatively associated with t^2 ($P<0.0001$). Its variance is negatively associated with t ($P<0.0001$).

The fitted mean curve of the percentage of women participants’ trend curve is shown in Figure 2. From Figure 2, it is clear that the increase rate of women participants’ is very low from 1900 to 1924, and it is almost stable from 1945 to 1975, and it increases from 1980, but it is almost stable from 2000 to 2016. Best of our knowledge, the current outcomes are not discussed in any earlier articles, so, these are completely new in the Olympic games literature. From the report, it is clear that the women participants’ trends are not quite satisfactory, and extra care should be taken in the future. Women's events are to be increased. Authorities of each nation, or country should take extra care on women's participation, or proper training of women to be experts on different sports.

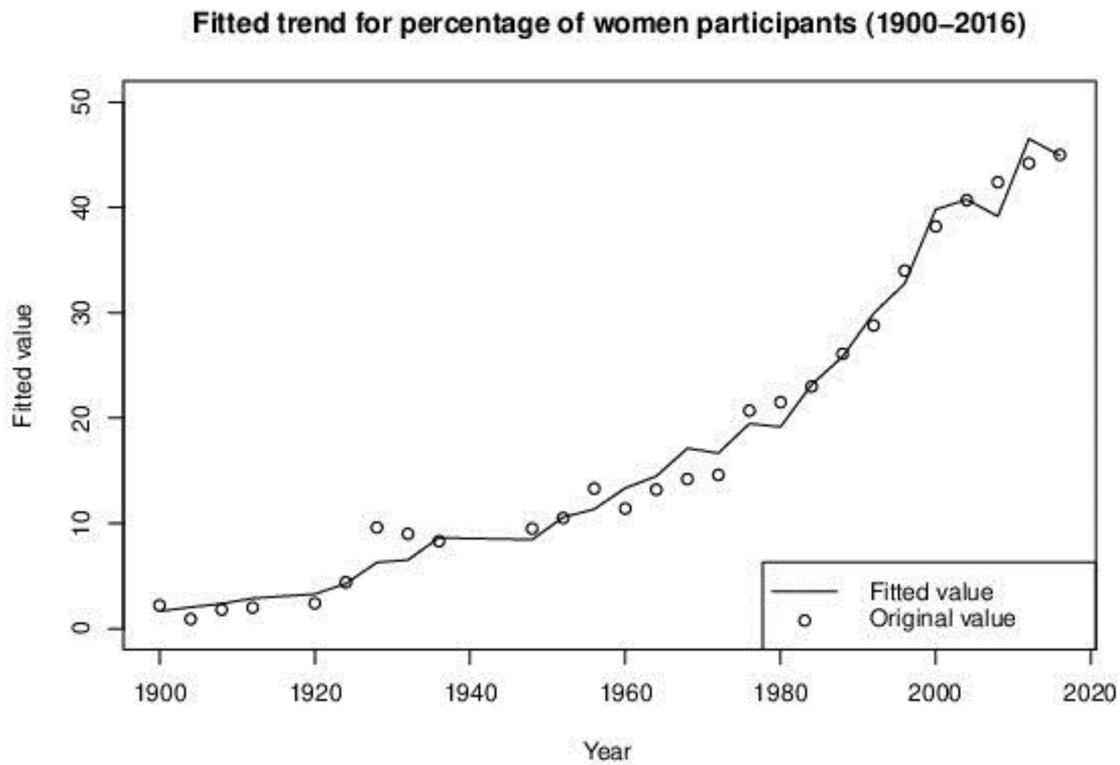

Figure No. 2: Fitted trend curve of the percentage of women participants' in the Olympic games over time

CONFLICT OF INTEREST: The authors confirm that this article's content has no conflict of interest.

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APPENDIX

Table No. 2: Olympic Games data for women participants

Year	Sports	Women events	Total events	% of women events	Women participants	% of Women participants
1900	2	2	95	2.1	22	2.2
1904	1	3	91	3.3	6	0.9
1908	2	4	110	3.6	37	1.8
1912	2	5	102	4.9	48	2
1920	2	8	154	5.2	63	2.4
1924	3	10	126	7.9	135	4.4
1928	4	14	109	12.8	277	9.6
1932	3	14	117	12	126	9
1936	4	15	129	11.6	331	8.3
1948	5	19	136	14	390	9.5
1952	6	25	149	16.8	519	10.5
1956	6	26	151	17.2	376	13.3
1960	6	29	150	19.3	611	11.4
1964	7	33	163	20.2	678	13.2
1968	7	39	172	22.7	781	14.2
1972	8	43	195	22.1	1059	14.6
1976	11	49	198	24.7	1260	20.7
1980	12	50	203	24.6	1115	21.5
1984	14	62	221	28.1	1566	23
1988	17	72	237	30.4	2194	26.1
1992	19	86	257	33.5	2707	28.8
1996	21	97	271	35.8	3512	34
2000	25	120	300	40	4069	38.2
2004	26	125	301	41.5	4329	40.7
2008	26	127	302	42.1	4637	42.4
2012	26	140	302	46.4	4676	44.2
2016	28	145	306	47.4	4700	45

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