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A Mathematical WGED – Model Approach on Short-Term High in Density Exercise Training, Attenuated Acute Exercise – Induced Growth Hormone Response

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ABSTRACT

In the current manuscript, we have demonstrated the recent generalization of Weibull-G exponential distribution (three-parameter) and it is a very familiar distribution as compared to other distribution. It has been found that Weibull-G exponential distribution (WGED) can be utilized pretty efficiently to evaluate the biological data in the position of gamma and log-normal Weibull distributions. It has two-shape parameters and the three scale parameters namely, a, b, λ. Some of its statistical properties are acquired, which includes reserved hazard function, probability-density function, hazard-rate function and survival function. Our aim is to shore-up the results of life-time using three-parameter Weibull generalized exponential distribution. Hence, the corresponding probability functions, hazard-rate function, survival function as well as reserved hazard-rate function has been analyzed in the 3 weeks of high-intensity exercise train-ing in short-term. The outcomes of the present study supporting the results of life-time data that the interim elevated intensity exercise activity attenuated an acute exercise induced growth hormone release.

1. Introduction

The Weibull models are employed to explain diverse types of observed failures of components and phenomena. The Weibull analyses are occupied on a single failure class and its applications are well-known for real life problems (Nassar et al. 2018). In the statistics literature, there are numerous additional Weibull-related distributions are accessible along with the conventional three, two-parameter Weibull distributions (WD) (Wais 2017). The medicine, engineering, insurance, economics and finance fields are using a number of standard theoretical distributions. However, generalizing these standard distributions has produced several compound distributions that are more flexible than base line distributions (Rinne 2008). Furthermore, researchers have made numerous efforts to intend the ideas to generate new sets of distributions, please refer Bourguignon et al. (2014) for further details.

A renowned continuous probability model, exponential distribution has been recognized as a life-time data analysis model among various other applications. Several attempts has been made to increase the flexibility of the exponential distribution that gave rise to the beta exponential distribution (Matheson and Cox C. 2017), generalized exponential distribution (Gupta and Kundu 2007), Kumaraswamy exponential distribution (Nofal et al. 2017), inverse-exponential distribution (Marcelo et al. 2014) and so on. In the present study, we interested to apply the Weibull Generalized family of distribution to analyze life-time data. The reason is that, there are three different forms of such class of distribution have been observed (Nasiru and Luguterah 2016; Bourguignon et al. 2014). Since 1958, Weibull distribution has been modified by many researchers (Almalki and Nadarajah 2014). Further, Gupta et al., proposed that the special case of distribution among the general class of exponentiated distributions is exponentiated Weibull distribution. The generalized exponential distribution's hazard function is pretty varied from the Weibull distribution's hazard function, in the other hand, it is more similar to the gamma distribution's hazard function; for further details, please refer Gupta and Kundu. Weibull-G exponential distribution has numerous advantages that it will offer an additional option to the researcher to analyzing the life-time data and this article will assist the researchers to get graphical solutions for life-time data analysis.

2. Methodology

2.1 Mathematical Model

2.1.1 Weibull G- Exponential Distribution (WGED)

The ED has a broad series of advantages in conjunction with clinical studies, applied statistics, reliability analysis

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and life-testing experiments. WGED is an incredible distribution of Weibull distributions two-parameter with the shape parameter equal to 1 (Gupta and Kundu 2001, 1999). The origin and other attitude of WGED would extract in a random variable X is supposed to encompass the ED with parameters $\lambda > 0$ if its probability-density function (PDF) is specified by $g(x) = \lambda e^{-\lambda x}, x > 0,$
Whereas the cumulative distribution function (CDF) is known by

$$G(x) = 1 - e^{-\lambda x}, x > 0$$

The survival function equationis,

$$S(x) = G(x) = 1 - e^{-\lambda x}, x > 0$$

And hazard function is

$$h(x) = \lambda$$

Weibull distribution introduced by Weibull, W. (1951) is one of the popular distributions for the modelling phenomenon with monotonic failure rates. If G (x) is the base-line CDF of a random variable with the Weibull CDF and PDF g(x) is

$$F(x;a,b) = 1 - e^{-ax^b}, x \geq 0 \quad ..(1.1)$$

With the parameters viz. a, b are optimistic. Depends on the density, by replacing x with ratio $\frac{G(x)}{1-G(x)}$ the CDF of Weibull generalized distribution is described by (bourguignon et al. 2014)

$$F(x;a,b,\lambda) = \frac{c(xl\lambda)}{\int_0^{1-c(x;\lambda)}} abt^{b-1} e^{-ax^b} dt \quad (1.2)$$

$$= 1 - e^{-a\left[\frac{c(x;\lambda)}{1-c(x;\lambda)}\right]}, x \geq 0, a, b \geq 0$$

Here $G(x;\lambda)$ is a baseline CDF, which depends on a parameter λ. The parallel personal PDF will turn into

$$f(x;a,b,\lambda) = ab\, g(x;\lambda) \frac{[G(x;\lambda)]^{b-1}}{[1-G(x;\lambda)]^{b-1}} e - a\left[\frac{G(x;\lambda)}{1-G(x;\lambda)}\right]^b \quad ..(1.3)$$

$\Pr(Y \leq x) = Pr\left(X \leq \frac{G(x)}{1-G(x)}\right) = F(x;a,b,\lambda)$ by the equation (1.2). Weibull G-family's survival function is

$$R(x;a,b,\lambda) = 1 - F(x;a,b,\lambda) = e^{-a\left[\frac{c(x)}{1-c(x)}\right]^b} \quad ..(1.4)$$

The hazard-rate function of the Weibull –G family is set by

$$h(x;a,b,\lambda) = \frac{f(x;a,b,\lambda)}{1-F(x;a,b,\lambda)} = \frac{abg(x;\lambda)[G(x;\lambda)]^{b-1}}{[1-G(x;\lambda)]^{b+1}}$$

$$= abg(x;\lambda)\frac{[G(x;\lambda)]^{b-1}}{[1-G(x;\lambda)]^b}$$

Where, the $h(x;\lambda) = \frac{g(x;\lambda)}{1-G(x;\lambda)}$ multiplying quantity $\frac{abg(x;\lambda)[G(x;\lambda)]^{b-1}}{[1-G(x;\lambda)]^b}$ works as a correction factor for hazard-rate function of the baseline model Eq. (1.2).
The exponential function using by power series,

$$e^{-a\left[\frac{c(x)}{1-c(x)}\right]^b} = \sum_{i=0}^{\infty} \frac{(-1)^i a^i}{i!}\left(\frac{G(x;\lambda)}{1-G(x;\lambda)}\right)^{ib} \quad ..(1.5)$$

$$f(x;a,b,\lambda) = \sum_{i=0}^{\infty} \frac{(-1)^i a^i}{i!} \frac{[G(x;\lambda)]^{b(i+1)-1}}{[1-G(x;\lambda)]^{b(i+1)+1}} \quad ..(1.6)$$

Using the generalized binomial theorem,

$$f(x;a,b,\lambda) = \sum_{i=0}^{\infty}\sum_{i=1}^{\infty} \frac{(-1)^i a^{i+1} b_r}{r^{(b(i+1)+j+1)}} \frac{(b(i+1)+j+1)}{j!} g(x,\lambda)[G(x;\lambda)]^{b(i+1)+j-1} \quad ..(1.7)$$

2.1.2. The Weibull Generalized Exponential Distribution (WGED)

We have studied the three-parameterWGED via above equations. The WGED is

$$f(x;a,b,\lambda) = 1 - e^{-a[e^{\lambda x}-1]^b} x > 0, \quad a,b,\lambda > 0.$$

The consequent pdf is

$$f(x;a,b,\lambda) = ab\lambda e^{\lambda x}\left[e^{\lambda x}-1\right]^{b-1} e^{-a[e^{\lambda x}-1]^b}, \; x > 0. \quad ..(1.8)$$

Where a, $b > 0$ and λ is selected value
$\lambda = 0.4, 0.3, 0.2, 0.1 > 0$

$$S(x;a,b,\lambda) = 1 - F(x;a,b,\lambda)$$

$$= e^{-a[e^{\lambda x}-1]^b} \quad x > 0,$$

$$h(x;a,b,\lambda) = ab\lambda e^{\lambda x}\left[e^{\lambda x}-1\right]^{b-1}, \quad ..(1.10)$$

$$r(x;a,b,\lambda) = \frac{ab\lambda e^{\lambda x}\left[e^{\lambda x}-1\right]^{b-1} e^{-a\left[e^{\lambda x}-1\right]^{b}}}{1-e^{-a\left[e^{\lambda x}-1\right]^{b}}} \quad ..(1.11)$$

3. Results

3.1. Application

3.1.1. Background

To establish an EG type-2 distribution, the life-time data was adopted from the Ritsche, K et al., 2014. Where, authors have performed the study with nineteen recreationally active male subjects at an age of 24.9 ± 3.9 yrs to analyse the levels of GH after acute exercise using the short term high intensity exercise training. Please refer Ritsche et al. 2014 for further explanation on experimental and study design. In the present study, we have acquired the following data (shown in Figure 1)

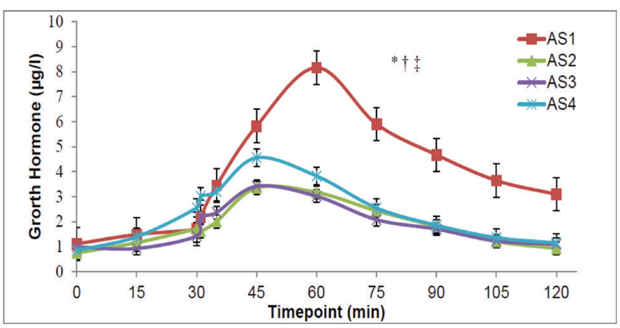

Figure 1: Shows a2-hr profileof Exercise-induced growth hormone with the 30-sec sprint at 30 minutes.

3.2 Mathematical Results

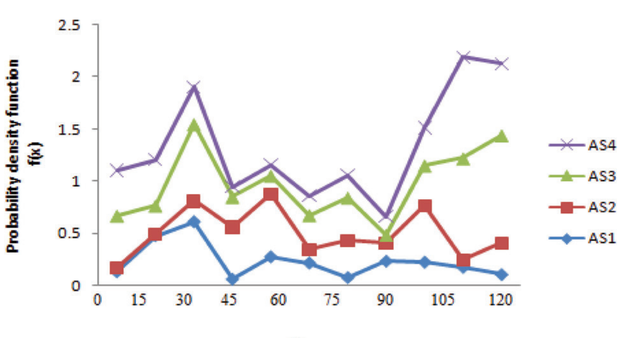

Figure 2: Represents the Weibull generalized exponential distribution probability density function $f(x)$ plots in retort to high force exercise training for short-term, an acute exercise-induced growth hormone level.

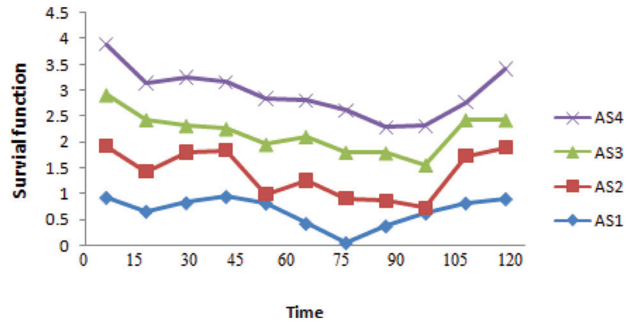

Figure 3: Shows the Weibull generalized exponential distribution survival function $s(x)$ plots in response to short-term high intensity exercise training for an acute exercise-induced growth hormone level.

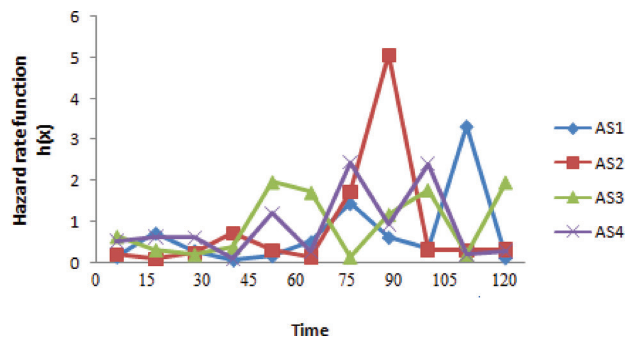

Figure 4: Depicts the Weibull generalized exponential distribution hazard function $h(x)$plots in retort to high force exercise training for short-term, an acute exercise-induced growth hormone level.

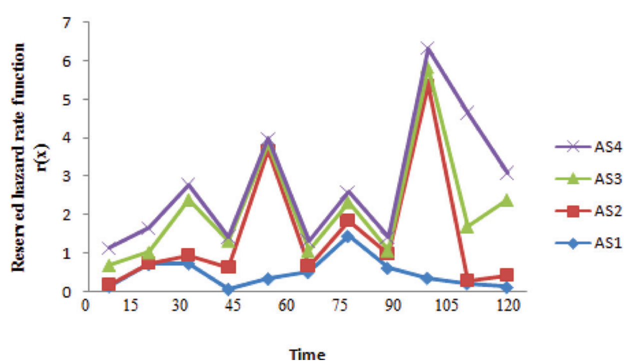

Figure 5: Depicts the Weibull generalized exponential distribution reserved hazard function $r(x)$ plots in retort to high force exercise training for short-term, an acute exercise-induced growth hormone level.

Conclusion

In the current manuscript, the Weibull generalized exponential distribution was employed to analyse the acute exercise-induced growth hormone level in retort to short-term high force exercise training after 120 minutes of 3^{rd} week (figures 2-5). These findings will enhance the understandings of secretary hormones (growth hormone) in the human endocrine system and further studies are need for clear elucidation. In conclusion, we have used the mathematical expressions with its necessary statistical distributions to analyze the life-time data that will deliberate the better understandings and this could be a narrative loom to analyze the life-time data in the future.

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