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Transmuted Fréchet Distribution for growth hormone during acute sleep deprivation

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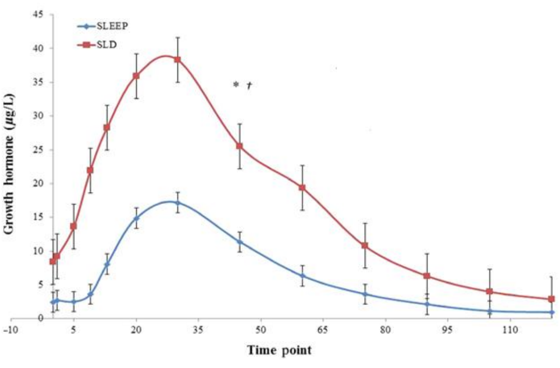
ABSTRACT
New parameters can be introduced to expand families of distributions for added flexibility or to construct covariate models and this could be done in various ways. In this paper we use Transmuted Fréchet Distribution to find GH response in sleep deprived individuals. The effect of acute sleep deprivation on exercise-induced growth hormoneand insulin-like growth factor-1 was examined. Ten mencompleted two randomized 24-h sessions including a brief,high-intensity exercise bout following either a night of sleep or sleep deprivation.
Keywords: TFD, GH, HR Function

I. INTRODUCTION

Human growth hormone (GH) is secreted from the anterior pituitary gland, which is heavily regulated by growth hormone-releasing hormone (GHRH) and somatostatin (SMS). In addition, GH output is mediated by ghrelin (GHS) and insulin-like growth factor-1 (IGF-1). GH is secreted in a pulsatile fashion, with the strongest physiologic stimuli being sleep and exercise. Humans spend approximately one-third of their lives sleeping (Morris et al. 2012). The major secretory GH pulse occurs just after sleep onset and continues to rise during the first 4 h. Most GH release occurs during nonrapid- eye movement (NREM) sleep within the slow-wave sleep (SWS) phase with little GH secreted during rapideyemovement (REM) sleep .Individuals undergoing some form of sleep deprivation, such as doctors, nurses, shift workers and military personnel, offer many of our important societal services. Additionally, athletes and coaches believe that sleep is essential for peak physical performance. There are many situations where sleep is disturbed prior to an athletic event including travel, changes in time zones and anxiety. Exponentially, student-athletes in higher education are forced to accommodate their study schedule for athletic events, resulting in altered sleep habits and/or sleep loss in order to study for exams. In these situations, the question arises as to how exercise may be used to neutralize the physiological effects of sleep deprivation in regard to GH(2, 7, 4). Sleep deprivation can alter hypothalamus and pituitary function, which de-synchronizes GH release timing the effects of acute sleep deprivation on subsequent exercise-induced GH release. Since we anticipated that GH production and storage would continue during a period of sleep deprivation followed by a subsequent bolus of release upon stimulation, we hypothesized that GH release will be augmented in response to short-term, high-intensity exercise following a 24-h period of continuous sleep deprivation.

Application

Exercise significantly increased blood lactate concentrations over resting values during both SLD and SLEEP sessions. However, no differences in blood lactate concentrations existed between SLD and SLEEP sessions at rest



Mean GH concentrations at each time point between SLEEP and SLD sessions during exercise and recovery. *Results indicated a significant interaction effect between time point and session ($P < 0.05$), and main effects for time point ($P < 0.01$) and session ($P < 0.05$). †Wilcoxon signed-rank tests indicated that exercise-induced GH concentrations were significantly lower at each timepoint during the SLEEP session from the onset of exercise (time point 0) through the remainder of the 120-min profile. Total GH AUC was significantly greater during the SLD versus SLEEP session ($P < 0.01$).

II. MATHEMATICAL MODEL

Transmuted Fréchet Distribution:

A random variable X is said to have a Fréchet distribution with parameters $\mu > 0$ and $\sigma > 0$ if its pdf is given by (1, 3)

$$g(x) = \mu\sigma^{\mu}x^{-(\mu+1)}e^{-(\frac{\sigma}{x})^{\mu}}, \quad x > 0$$

The cdf of X is (5)

$$G(x) = e^{-(\frac{\sigma}{x})^{\mu}}$$

the cdf of transmuted Fréchet distribution (5) with parameters μ, σ and λ takes the form

$$F(x) = (1+\lambda)e^{-(\frac{\sigma}{x})^{\mu}} - \lambda\left[e^{-2(\frac{\sigma}{x})^{\mu}}\right]$$

$$= e^{-(\frac{\sigma}{x})^{\mu}}\left[1 + \lambda - \lambda\, e^{-(\frac{\sigma}{x})^{\mu}}\right], |\lambda| \le 1$$

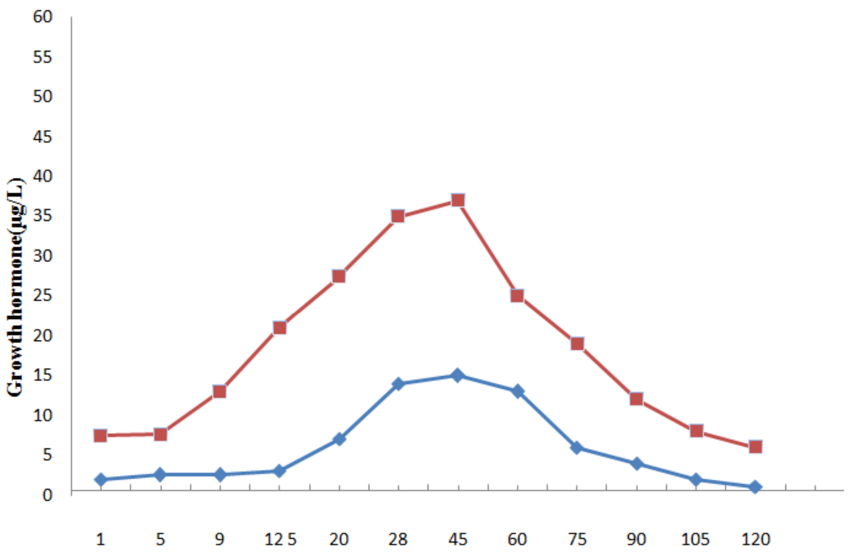
and the pdf of transmuted Fréchet distribution with parameters μ, σ and λ becomes

$$f(x) = \frac{\mu}{\sigma}(\frac{\sigma}{x})^{\mu+1}e^{-(\frac{\sigma}{x})^{\mu}}\left[1 + \lambda - 2\lambda e^{-(\frac{\sigma}{x})^{\mu}}\right], \quad x > 0, \mu, \sigma > 0 \; and |\lambda| \le 1.$$

The Fréchet distribution is clearly a special case for $\lambda = 0$. The hazard rate function for the transmuted Fréchet random variables (6) is given by

$$h(x) = \frac{\frac{\mu}{\sigma}(\frac{\sigma}{x})^{\mu+1}e^{-(\frac{\sigma}{x})^{\mu}}\left[1 + \lambda - 2\lambda e^{-(\frac{\sigma}{x})^{\mu}}\right]}{1 - e^{-(\frac{\sigma}{x})^{\mu}}\left[1 + \lambda - \lambda e^{-(\frac{\sigma}{x})^{\mu}}\right]}$$

S.No	**x**	**h(x)**
1	.1	0
2	.7	2.2260
3	1.2	1.4034
4	1.7	1.3006



Time Point

SLEEP

X	1	5	9	12.5	20	28	45	60	75	90	105	120
Y	2	2.5	2.5	3	7	14	15	13	6	4	2	1

SLD

X	1	5	9	12.5	20	28	45	60	75	90	105	120
Y	7.5	7.6	13	21	27.5	35	37	25	19	12	8	6

III. CONCLUSION

By using new parameters and by the method of transmuted distributions we found cumulative distribution, pdf of transmuted Freclet distributions for GH concentration at each time point. We found GH release during sleep deprivation to elicit a maximal GH response greater than exercise following a night of adequate sleep between SLEEP &SLD session during exercise and recovery.

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