Electronic Physician (ISSN: 2008-5842) http://www.ephysician.ir
April-June 2019, Volume: 11, Issue: 2, Pages: 7468-7470, DOI: http://dx.doi.org/10.19082/7468

Parametric test for non-normally distributed continuous data: For and against

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Type of article: Editorial

Abstract

Choosing between parametric and non-parametric statistical tests for analysis of non-normally distributed continuous data is a long-standing controversy. Conventionally, it is recommended to use non-parametric tests but few others suggest using the parametric test. This article evaluates the simulation studies comparing the parametric tests with non-parametric tests in analysing the non-normally distributed continuous data. Non-parametric tests are recommended only when data is highly skewed and log transformation technique cannot change it to normal distribution. However, in most other situations parametric tests are more powerful in analysing non-normally distributed continuous data.

Keywords: Biostatistics, Data analyses, Non-parametric statistics, Normal distribution

Note:
This is a solicited editorial and Dr. Umesh Wadgave is an Associate Editor of Electronic Physician. Because of presence of non-normally distributed data in some of the manuscripts submitted to biomedical journals- and to Electronic Physician, the journal has invited the authors of this editorial, to discuss on the long-standing controversy issue of choosing between parametric and non-parametric statistical tests.

Acronyms / Abbreviations:
WMW: Wilcoxon-Mann-Whitney, also called the Mann–Whitney–Wilcoxon (MWW) or the Mann–Whitney U test;
WSR: Wilcoxon signed-rank

INTRODUCTION

It is a long-standing debate whether parametric tests are applicable to non-normally distributed continuous data or not (1). Conventionally, it is recommended that for applying parametric statistical methods, data should be normally distributed. If not, alternative non-parametric statistical methods should be employed (2). Unfortunately, choosing non-parametric over parametric statistical methods is not that straightforward. We have to consider several other factors while choosing statistical methods such as the probability of committing type I or type II error (1). The only way to resolve this controversy is to evaluate the evidence of several simulation studies comparing the potential of parametric statistics with non-parametric statistics for non-normally distributed continuous data. This article

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Received: January 15, 2019, Accepted: March 11, 2019, Published: June 2019
iThenticate screening: March 11, 2019, English editing: March 15, 2019, Quality control: April 02, 2019
This article has been reviewed / commented by three experts
Funding: This article did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.
Ethics approval: Not applicable, as this article is an Editorial and don't involve humans or animals.

reviewed the simulation studies comparing the properties of parametric statistics with non-parametric statistics and attempts to suggest the appropriate statistical design for non-normally distributed continuous data.

EVIDENCE AGAINST PARAMETRIC STATISTICS

Non-parametric tests are considered more powerful for the analysis of studies with the small sample and/or non-normally distributed data. Two simulation studies have demonstrated that both Wilcoxon-Mann-Whitney (WMW) and Wilcoxon's signed-ranks test are more powerful than the unpaired t-test and paired t-test respectively in analysing non normally distributed data (3, 4). Another study showed, WMW is asymptotically more powerful for t-distributions with degrees of freedom less than 18 (5). Studies have demonstrated that in analysing extremely skewed data Wilcoxon signed-rank (WSR) test held greater power advantages than paired t-test, and t-test was inefficient to control Type I and II error (6, 7).

EVIDENCE FAVOURING PARAMETRIC STATISTICS

Basically, the parametric test depends on the assumption of the normal distribution of the sample means, not of data (8). Therefore, the assumption of normality cannot be considered a very strong requirement for parametric tests' application. According to the central limit theorem, in small sample sizes, sampling distribution of means will be normal if the sample data are approximately normal and in large samples [> 30 or 40], the sampling distribution of means tends to be normal, regardless of the shape of the data (9). Even the use of normality tests to check deviation from normal distribution of data are not considered valid because they have less power in small sample sizes and they become very sensitive in large sample sizes. It should also be noted that parametric tests are not affected by small deviation in normal distribution of continuous data (1, 10, 12). Misconception about normality assumption (i.e. distribution of sample means not of data), high tendency of sample means for normal distribution, limitation of normality tests to detect deviation in normal distribution and robustness of parametric tests to small deviation, favours the application of parametric tests for the analysis on non-normally distributed continuous data.

Several simulation studies have demonstrated that parametric statistics such as t-test, modified t-test, and Welch U test were more robust than their non-parametric counterparts to type I error, type II error and the power calculations for non-normally distributed data with different variances and sample sizes (6, 7, 12-15). On the other hand, Analysis of covariance test was more efficient than Man-Whitney test in analysing log transformation of extremely skewed data of a randomized trial (2).

Parametric tests have a few other advantages over non-parametric methods such as; first, for very small sample sizes of 2 or 3, parametric test have the ability to show the significant difference which is not possible with non-parametric tests., second, highly skewed continuous data can be converted to normal distribution with log transformation technique before employing parametric tests, and third, estimates and confidence intervals can easily be produced by parametric tests, which is not directly possible by non-parametric tests (16).

CONCLUSIONS

The existing evidence from simulation studies suggests that parametric methods are preferred over non-parametric in most situations while analysing non-normally distributed continuous data. Even though non-parametric tests are independent of normality assumption, they depend on equal shape and variance of the two distributions [homoscedasticity] (12). So, non-parametric tests should only be considered for the continuous data when the distribution is highly skewed and log transformation cannot change it to normal distribution and when normality of these data cannot be assumed from reports of these data elsewhere (16). Considering the limitation of normality tests' application to both large and small sample sizes, it is advised to assess the magnitude of skewness of data distribution with graphical methods.

Funding:
This article did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

Conflict of Interest:
There is no conflict of interest to be declared.

Authors' contributions:
Both authors contributed to this article equally. Both authors read and approved the final manuscript.

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