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SHORT COMMUNICATION

Statistics in Three Biomedical Journals

T. PILČÍK

Institute of Molecular Genetics, Academy of the Sciences of the Czech Republic, Prague, Czech Republic

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Summary

In this paper we analyze the use of statistics and associated problems, in three Czech biological journals in the year 2000. We investigated 23 articles Folia Biologica, 60 articles in Folia Microbiologica, and 88 articles in Physiological Research. The highest frequency of publications with statistical content have used descriptive statistics and t-test. The most usual mistake concerns the absence of reference about the used statistical software and insufficient description of the data. We have compared our results with the results of similar studies in some other medical journals. The use of important statistical methods is comparable with those used in most medical journals, the proportion of articles, in which the applied method is described insufficiently is moderately low.

Key words

Statistics • Usage • Biomedical journals • Assessment

Statistical analysis is an inseparable part of scientific publications, including the field of biology and genetics. The results of experiments have to be analyzed statistically in an adequate manner, if the observations or/and measurements are obtained in more than one object, or/and more than once. Nowadays, this requirement applies to most scientific investigations. Statistical analysis helps to arrive closer to the core of the problem. Results of adequate statistical analysis can inspire new hypotheses. On the other hand, the results of an incorrect one are likely to cause errors and confusion.

However, statistical analysis is not always applied with a sufficient amount of knowledge and care. Quite often the statistical software lacks the required quality (McCullough 1998, 1999, McCullough and Wilson 1999). If the data are analyzed by scientists not trained in statistical analysis and without access to statisticians, the advantages of statistical methods are often not fully utilized. Some procedures are applied without complying with the input conditions that are necessary for their correct interpretation.

For this review, we selected three journals published by institutes of the Academy of Sciences of the Czech Republic (ASCR) in Prague in 2000: Folia Biologica (Prague), vol. 46 (published by the Institute of Molecular Genetics of ASCR), Folia Microbiologica, vol. 45 (published by the Institute of Microbiology of ASCR), and Physiological Research, vol. 49 (published by the Institute of Physiology of ASCR). The subtitle of Folia Biologica is "Journal of cellular and molecular biology", and that of Folia Microbiologica is "International journal for general, environmental and applied microbiology, and immunity". Physiological Research publishes papers from the field of animal and human physiology and

biology. For all these journals, the impact factor has been calculated by ISI for the year 2001 (ISI 2002): for Folia Biologica 0.519, for Folia Microbiologica 0.776, and for Physiological Research 1.027.

We have analyzed all publications, in which statistical analysis was done, or should be done. The number of publications in Folia Biologica was 47 (analyzed 23), in Folia Microbiologica 99 (analyzed 60), and in Physiological Research 115 (analyzed 88). The journals published several review articles: Folia Biologica: 6, Folia Microbiologica: 4, Physiological Research: 23.

Applied statistical methods were classified into eleven categories according to Emerson and Colditz (1983) (Table 1.).

Failures and mistakes in statistical analysis of experimental data were classified according to Altman 1998 (Table 2.).

Our criteria for correct statistical analysis in scientific publications are in concordance with the recommendations of the International Committee of Medical Journals Editors (ICMJE 1997). A dataset was classified as too small if the number of observations per group was less than five. This number is usually presented in statistical textbooks as the minimum, although in some situations it can also be too small (c.f. Meloun and Militký 1994, p. 93).

Table 1. Categories of statistical methods employed

No statistics	No statistical analysis present
Descriptive statistics	Estimate of mean, median, variance, their graphical representation
t-test	One-tailed or two-tailed, for paired samples
Contingency table	Chi-square test, Fisher's exact test
Simple linear regression	Least-squares regression with one predictor and one response variable
Analysis of variance	Analysis of variance, analysis of covariance
Multiple comparison procedure	Bonferroni techniques, Duncan multiple range procedures, Newmann-Keuls procedure
Correlation analysis	Pearson's correlation coefficient
Nonparametric hypothesis testing	Wilcoxon test, Mann-Whitney test, Kruskal-Wallis test
Other	None of the above (e. g. multiple regression, nonparametric correlation)
Cannot be determined	Missing information about the statistical method

Table 2. Categories of inappropriate statistical analysis

Insufficient statistical analysis	The experimental data were analyzed insufficiently or not at all
Insufficient data description	Insufficient or missing descriptive statistics, the number of objects per group is not given
Insufficient description of methods	The information necessary for identifying the used method is missing
Statistical software not cited	Used statistical software cited insufficiently or not at all
Unsuitable parameters for presentation	For example S.E. instead of S.D.
No control of fulfilling input conditions (for some statistical methods)	No normality or homogeneity of variances is tested by using some parametric methods
Unsuitable statistical method	Inapproprial method chosen for analysing of data, using e. g. multiple t-tests instead of ANOVA
Data set too small	Insufficient number of observations

Table 3. Number of publications in the analyzed journals

Number of publicatins	Folia Biologica		Folia Microbiologica		Physiological Research	
	n	%	n	%	n	%
Total (including review articles)	47	100	99	100	115	100
With statistical content	23	48.9	60	60.6	88	76.5

Table 4. Statistical methods used in the publications with statistical content

Methods	Folia Biologica		Folia Microbiologica		Physiological Research	
	n	%	n	%	n	%
No statistical method	2	8.7	25	41.7	3	3.4
Descriptive statistics	15	65.2	31	51.7	80	90.9
T-test	10	43.5	3	5.0	38	43.2
Contingency tables	3	13.0	0	0	6	6.8
Simple linear regression	0	0	2	3.3	3	3.4
Analysis of variance	3	13.0	4	6.7	32	36.4
Multiple comparison procedure	2	8.7	5	8.3	17	19.3
Correlation analysis	0	0	1	1.7	3	3.4
Nonparametric hypothesis testing	3	13.0	1	1.7	9	10.2
Other	4	17.4	1	1.7	9	10.2
The method cannot be determined	5	21.7	9	15	10	11.4

The largest number of publications was published in Physiological Research, the smallest number in Folia Biologica (Table 3). The same applies to publications with a statistical content.

The highest frequency of publications with statistical content (apart from those using descriptive statistics) have used the t-test. In most articles published in Folia Microbiologica, the necessary statistics are missing (Table 4). The third most frequent category are publications, in which the applied method cannot be determined because of lack of information. Linear regression and correlation analysis had been rarely applied. The most frequent mistake is the absence of information about the used statistical software in Folia Biologica and Physiological Research, and the insufficient description of data in Folia Microbiologica (Table 5). The second most frequent shortcoming is the insufficient description of used methods in Folia Biologica, insufficient statistical analysis in Folia Microbiologica, and both insufficient description of used methods and presentation of results by unsuitable parameters in Physiological Research. Finally, a check of fulfilling the input conditions of some methods is missing (Folia Biologica and Physiological Research). The reference to statistical software employed is also missing (Folia Microbiologica).

The use of descriptive statistics deserves additional comment (Table 6). The highest frequency of publications with descriptive statistics as the most sophisticated statistical method is given in Folia Microbiologica. In the same journal, the highest number of publications occurs, where application of descriptive statistics was not fully used to extract all information from the data. In Folia Biologica, most publications of all three journals (26.1 %, Table 6) that have used some advanced statistical methods, circumvented the descriptive statistics.

The use of statistics in the three reviewed journals is well comparable with its use in medical journals (Emerson and Colditz 1983, Rosenfeld and Rockette 1991).

Table 5. Shortcomings in the correct use of statistical methods in reviewed publications

Error	Folia Biologica		Folia Microbiologica		Physiological Research	
	n	%	n	%	n	%
Insufficient statistical analysis	5	21.7	33	55.0	7	8.0
Insufficient data description	7	30.4	35	58.3	18	20.5
Insufficient description of methods	14	60.9	10	16.7	50	56.8
Statistical software not cited	15	65.2	26	43.3	75	85.2
Unsuitable parameters for presentation	7	30.4	3	5.0	50	56.8
No control of fulfilling input conditions	10	43.5	8	13.3	38	43.2
Unsuitable statistical method	5	21.7	2	3.3	20	22.7
Too small dataset	1	4.3	2	3.3	3	3.4

Table 6. Using of descriptive statistics (DS)

Journal	No. of articles analyzed	DS only		DS insufficient		DS missing, although required	
	n	n	%	n	%	n	%
Folia Biologica	23	1	4.3	1	4.3	6	26.1
Folia Microbiologica	60	17	28.3	6	10.0	4	6.7
Physiological Research	88	10	11.4	1	1.1	5	5.7

In comparison with the results of Rosenfeld and Rockette (1991), who analyzed the application of statistical methods in otolaryngology journals (all comparisons are done with their values from year 1989), the use of descriptive statistics alone was not so frequent in the analyzed Czech scientific journals (4.3 % in Folia Biologica, 28.3 % in Folia Microbiologica and 11.4 % in Physiological Research compared with 39.2 %). The t-test was applied more often (about 45 % in Folia Biologica and Physiological Research, compared with 11.8 % in publications reported by Rosenfeld and Rockette 1991), as well as contingency tables (13 % in Folia Biologica compared with cca 9.6 % by Rosenfeld and Rockette, 1991) and ANOVA (13 %, 6.7 % and 36.4 %, respectively, compared with 4.7 %). Part of these differences may be due to the different type of data in clinical as opposed to experimental research papers.

If we compare the shortcomings in reviewed publications with the similar analysis of Altman 1998 (data from years 1991-1993), we can see, e.g. a lower proportion of publications in which the applied method is described insufficiently (39.1 % in Folia Biologica, 15 % in Folia Microbiologica, and 19.3 % in Physiological Research in comparison to Altman's 53 %). The proportion of insufficiently described both data and methods do not enable us to compare our results with those of other authors.

Our analysis shows that a more informed and careful application of statistical methods by the authors and increased awareness of the reviewers are likely to improve the scientific quality of publications in the three analyzed journals. Changes in the Instructions to Authors regarding the description of applied statistics and changes in the attitude of researchers and editors might lead to considerable improvement in the quality of statistics in published papers (Welch and Gabbe 1996, 2002).

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Reprint requests

T. Pilčík, Institute of Molecular Genetics Academy of the Sciences of the Czech Republic, Flemingovo nám. 2, Prague 6, 166 37, Czech Republic. E-mail: pilcik@img.cas.cz