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Effectiveness of Some Educational Methods and Tools on Improving the Level of Understanding of Biostatistics among Medical Students and Paramedical Postgraduate Students

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Abstract

It has been observed that medical students and researchers lack sufficient knowledge in understanding statistical concepts. This indicates the importance of improving the level of instruction in this field. This experimental study was conducted to introduce and investigate the effectiveness of some educational methods and tools in improving the level of understanding of biostatistics among medical students and paramedical postgraduate students. For this purpose, from 40 medical students and 20 paramedical postgraduate students, who attended the biostatistics course, pre-test and post-test questionnaires were collected. The medical students were divided into two training groups, namely, training with the help of software (intervention group), and the traditional (lecture method) group. The paramedical postgraduate students were also divided into two groups, except that for the intervention group, in addition to training with the help of software, educational DVDs were also provided. Knowledge, attitude and the awareness index of the students were determined by using a questionnaire. Post-test results indicate that, the awareness index in the intervention group was significantly higher than the control group ($P<0.05$). The new method of teaching significantly upgraded the knowledge of the students ($P<0.05$) and increased the level of attitude of the medical students ($P<0.04$). Comparing the post-test results of the two groups, i.e., medical students and paramedical postgraduate students, demonstrated that a combination of software and instructional DVDs had a positive effect on the desired outcome ($P<0.01$). Usage of statistical software and additional virtual methods will contribute to increasing the level of knowledge and attitude of the students toward biostatistics. The training method and, accordingly, the curricula of biostatistics courses in medical and paramedical schools must be revised.

Keywords: educational technology, statistical software, training method

1. Introduction

With the scientific and policy perspectives of the future, a growing need of medical students and researchers in biostatistics is undeniable. According to some studies, many published medical research articles contain statistical errors (Strasak et al., 2007). The teaching of biostatistics and the problems of medical students in understanding statistical concepts is a topic presented in many sources (Akinsola et al., 2014; Altman & Bland, 1991; Polychronopoulou et al., 2011; Windish, 2011). The negative attitude of students towards statistics has been repeatedly reported (Martin, 2003; Ograjenšek & Bavdaž Kveder, 2003; Ograjenšek, 2005), and a review of the literature indicates that the level of understanding of medical students and practitioners of biostatistics is very low (Maha & Tantawi, 2009). Gore et al. believe that it is essential for medical professionals to upgrade their biostatistics knowledge frequently in order to improve research quality (Gore et al., 2012).

Studies show that only 21 percent of physicians correctly understand the interpretation of data in articles (Ghajarzadeh, Abdollahzadeh, & Rafiei, 2011; Windish, Huot, & Green, 2007). These studies show that although medical statistics is taught at all levels of education, its effectiveness is questionable. In the study, conducted in the United States of America, 277 medical residents (75.5%) acknowledged that they did not understand 75% of the concepts of biostatistics in articles, while 95% of them felt that it was important to understand these concepts**.** This means that most of the residents in this research had a deficient knowledge in the field of

biostatistics and needed help in interpreting the results published in medical journals. As a result, resident training programs should include teaching statistics more effectively in order to prepare students for important long-term learning skills (Wulff et al., 1987).

In a research conducted in the field of dentistry in the United States, with the aim of assessing the understanding of statistics, the results show that the residents of maxillofacial surgery have little knowledge of statistics. Therefore, curricula of residency courses should include a higher level of statistical education (Best & Laskin, 2013). In a study aimed at evaluating the cognition, comprehension and application of biostatistics in research among postgraduate students in periodontics in India, Swetha et al. found that 80% of students were aware of the importance of biostatistics in research, while only 3.0% were able to perform statistical analysis independently. They concluded that the level of understanding and application is low, and further attention in this regard is required (Swetha et al., 2014). According to the Daher and Amin (2010) study, which was conducted to explore medical students' attitude toward biostatistics, the students understood the relevance of the subject to real health issues, but a majority of the students (78.1%) agreed that a lack of practicing exercises was the cause of declining interest in the subject, while 84.6% recommended practical sessions for designing research and data collection (Daher & Amin, 2010).

In order to find reasons for the lack of knowledge of statistics of medical practitioners, Stander conducted a study which addresses the time allotted to the course, its content, teachers' methods and the quality of their lectures. It concludes that in order to motivate medical students to learn statistics, substantial change in the method of teaching is required (Stander, 1999). In a survey by West and Ficalora (2007), it is shown that only 17.6% of medical students, internal medicine residents, and internal medicine teaching faculties believe that they have acceptable training in biostatistics, and only 14.6% feel prepared to conduct a statistical analysis (West & Ficalora, 2007). In teaching statistics there are some references which suggest that incorporation of various techniques to actively involve the students in the learning process, such as working through some examples, discussing practical issues, etc. are effective (Gelman, 2005). Research has shown that educational technology is an effective factor in teaching statistics (Chance et al., 2007). Therefore, the selection of an appropriate instructional method, or a combination of several different methods, can lead to increased training efficiency.

In this study an attempt has been made to introduce educational methods for teaching biostatistics and investigate their effectiveness in the knowledge and attitude of medical science students. Since biostatistics is one of the subjects of medical and paramedical postgraduate courses, in this study both groups were considered for further investigation.

2. Methods

This experimental study was carried out at Shahid Beheshti University of Medical Sciences in Iran.

2.1 Participants' Characteristics

From among classrooms of biostatistics of medical students and postgraduate paramedical students (P.G.) some classrooms were randomly selected as clusters, all the students of each classes were eligible to participate in the study. If someone didn't wish to participate, s/he was excluded from the study. Postgraduate paramedical students were from different streams, like nursing, lab. Sciences, physiology and so on.

2.2 Sampling Procedure

2.2.1 Research Design

In the medical group, clusters were randomly divided into two groups: A classroom as intervention group, in which the method of training was with the help of software, and some other classrooms as control group, in which the common traditional method, i.e., the lecture method was used. In the postgraduate group, classrooms were also divided into two groups, with the difference that the intervention group was not only trained with the help of software, but was also provided with instructional DVDs, so that whenever they felt the need they would be able to hear and see the description of the teacher.

2.2.2 Measures and Covariates

In order to collect data, a standard questionnaire previously used for medical students was used (Ghajarzadeh et al., 2011). With regard to the validity and reliability of the questionnaire, the same paper was cited. The questionnaire consisted of 8 questions on the Likert scale (from 1: absolutely disagree to 5: absolutely agree) that was used to determine the extent of the knowledge and attitude of students toward biostatistics. Questions 1, 3, 4, 5 measure the attitude of the students (Attitude index on the scale 4-20), and the remaining questions were used to measure their knowledge (Knowledge index on the scale 4-20). The awareness index was defined using all the

8 questions contained in the questionnaire, on the scale 8-40. Considering that the third question is in the opposite direction, it should be calculated in reverse. In order to assess the effectiveness of the intervention on the students' knowledge and attitude, the questionnaire was administered to the students, once at the beginning and again at the end of the semester. If the students of the traditional class and intervention class had no significant differences with each other at the beginning of the semester, after intervention, results of the two groups were compared by using the Mann-Whitney test. However, if at the baseline there were significant differences between the groups, adjustment has been made by eliminating the effect of the baseline.

2.2.3 Sample Size Determination

To determine the sample size, a pilot study was carried out. The standard deviation of the awareness index was found to be 4, considering α=0.05, β=0.2, d=4.3 the minimum sample size of 11 was found for each group.

2.2.4 Interventions

For medical students, intervention would be on the basis of teaching biostatistics via lecture and software simultaneously. In this method, in addition to learning the theory of biostatistics, students have to employ statistical software to solve the exercises. The control group was taught by the traditional method, i.e., lecture. In the case of paramedical postgraduate students, in order to intervene, in addition to the statistical software, instructional DVDs were also provided. The reason for providing instructional DVDs was that according to the author's experience, it was observed that postgraduate students needed more explanation about the topic, therefore the DVDs could help the students to review the subject repeatedly.

Considering that in the traditional method the students must solve statistical exercises manually, at most using a calculator, it is not possible for an instructor to cover complicated formulae and methods. However, in the new method students can perform data analysis by using statistical software without wasting time or facing great difficulty. On that basis, Table 1 shows the curricula that were used in the two methods – the traditional and the new method, comparatively.

Table 1. Comparative curricula of biostatistics at the medical and paramedical postgraduate level

Traditional method	New method
Definitions and Terms	Definitions and Terms
Ways of data collection. Types of variables	Ways of data collection. Types of variables Computerization of data
Descriptive statistics with a small samples as examples, using a calculator	Descriptive statistics of data by using computer without any limitation in sample size
Central Tendency (Mean, Median, Mode) Quartiles Measures of Dispersion	Central Tendency (Mean, Median, Mode) Quartiles, Percentiles Measures of Dispersion
Histogram, Bar diagram, Pie diagram, Error bar, Polygon, Cumulative polygon	Histogram, Bar diagram, Pie diagram, Error bar, Box plot (with outliers), Polygon, Cumulative Polygon, Scatter diagram, Normal Curve.
Z – tests t – tests P-value	Z – tests t – tests P-value Relevant Non-parametric tests
One Way Analysis of Variance	One-way analysis of variance Relevant non-parametric tests Two-way analysis of variance Analysis of covariance
Chi – Square	Chi-square Fisher exact test

The local ethical registration number of the study is 131-91/12/6. Students were assured of the confidentiality of their answers. Written consent was obtained from all participants. Data analyses were done by SPSS (16).

3. Results

3.1 Recruitment

At the beginning of the semester, 2011-2012, 140 medical students and 52 paramedical postgraduate students were recruited to the study.

3.2 Baseline Data

Table 2 shows the details of the demographic profile of the samples.

Table 2. Percentage or mean (SD) of the demographic characteristics of the samples–Shahid Beheshti University of Medical Sciences, 2012

	Medical Students	**Paramedical Postgraduate Students**
Sex (%Boys)	46	**25**
Age (Year) (Mean(SD))	21(1)	**26(5)**
Previous familiarity with statistics (%)	6	**76**

3.2 Statistics and Data Analysis

As it is shown in Table 2, the mean of the age of medical students and P.G.s are 21 and 26, respectively; meaning that medical students are younger than P.G.s. On the other hand, a very low percentage of medical students had previous familiarity with statistics compared to the postgraduate group (6% vs. 76%). Due to these differences, data analyses were performed separately.

Table 3 represents the mean (SD) of variables, before and after intervention, among medical students with respect to the teaching method, i.e., the new and traditional methods. The results show that the traditional approach has been able to upgrade the averages related to the questions 6, 7 and 8 significantly. The averages in rows 1, 2, 6, 7 and 8 have been dramatically increased in the new method ($P<0.05$).

In the traditional method, question 5 "As an intelligent reader of medical references, it is required to know statistics to some extent", shows that the estimated mean has dropped from 4.1 to 3.2, before and after intervention, respectively ($P<0.013$). The mean of the knowledge of the medical students in the new method changed from 8.2 in pre-test to 12.2 in post-test ($P<0.0005$), while in the traditional method it changed from 9.4 to 11.7 ($P<0.005$). The difference between the means of the knowledge index of the two groups at the end of the semester was found to be significant (12.2 vs. 11.7) ($P<0.03$). The post-test mean of the attitude index of the medical students significantly increased in intervention group compared to the control group (14.4±3.4 vs. 12.3±3.7) ($P<0.04$). It is noticeable that the attitude of the students in the traditional method decreased significantly, from 14.1 at the beginning of the semester to 12.3 at the end ($P<0.05$). The average of the awareness index among medical students in the new method, before starting the semester, was found to be 21.9, and at the end of the semester it was found to be 26.6, which are significantly different ($P < 0.0005$), indicating the effectiveness of the new method. However, no significant differences were observed between before and after the traditional method in this score, 23.6 and 23.8, respectively. The post-test awareness index in the intervention and control groups, was significantly different (26.6±5.7 vs. 23.8±5.9, $P<0.02$).

Table 3. The mean (SD) of the questions responded to by medical students according to the method of training before and after intervention–Shahid Beheshti University of Medical Sciences, 2012

	Question		New Method	Traditional Method	Sig
			Mean (SD)	Mean (SD)	
1	I (as a medical student) like to learn more statistics.	Pre-test	3.0(1.1)	3.1(1.1)	**0.4**
		Post-test	3.4(1.3)	2.8(1.4)	**0.1**
	Sig		0.05	0.2	
2	I understand almost all the statistical phrases in the journals.	Pre-test	2.6(0.9)	2.6(0.9)	**0.5**
		Post-test	2.9(0.8)	2.7(0.9)	**0.4**
	Sig		0.05	0.8	
3	In medical research, I think knowledge of statistics is not required.	Pre-test	1.9(1.1)	2.0(1.1)	**0.7**
		Post-test	2.0(1.2)	2.4(1.3)	**0.3**
	Sig		0.8	0.2	
4	I generally feel I have to use statistics to reach a medical decision.	Pre-test	2.8(1.0)	2.9(1.0)	**0.4**
		Post-test	3.0(1.1)	2.6(1.0)	**0.2**
	Sig		0.3	0.2	
5	As an intelligent reader of medical references, it is required to know statistics to some extent.	Pre-test	3.8(1.0)	4.1(1.0)	**0.09**
		Post-test	4.0(1.0)	3.2(1.3)	**0.03**
	Sig		0.4	0.013	
6	I understand the interpretation of p-value as mentioned in medical studies.	Pre-test	1.4(0.7)	1.8(1.1)	**0.01**
		Post-test	2.8(1.2)	3.0(1.2)	**0.6**
	Sig		0.0005	0.0005	
7	I can interpret the statistical results of medical studies.	Pre-test	2.2(1.0)	2.6(1.0)	**0.03**
		Post-test	3.4(0.8)	3.3(0.9)	**0.04**
	Sig		0.0005	0.01	
8	I can suggest an appropriate statistical method in order to answer the research questions.	Pre-test	2.1(1.0)	2.4(0.9)	**0.04**
		Post-test	3.2(1.1)	2.9(1.0)	**0.04**
	Sig		0.0005	0.03	
	Knowledge Index	Pre-test	8.2(2.7)	9.4(2.9)	**0.02**
		Post-test	12.2(3.0)	11.7(3.0)	**0.03**
	Sig		0.0005	0.005	
	Attitude Index	Pre-test	13.6(3.0)	14.1(2.9)	**0.5**
		Post-test	14.4(3.4)	12.3(3.7)	**0.04**
	Sig		0.1	0.05	
	Awareness Index	Pre-test	21.9(4.3)	23.6(4.4)	**0.03**
		Post-test	26.6(5.7)	23.8(5.9)	**0.02**
	Sig		0.0005	0.8	

Table 4 shows the mean (SD) of the questions to which the paramedical postgraduate students responded, according to the method of training before and after intervention. The impact of the traditional training, before and after intervention, is related only to items 6 and 7. The effect of the use of software and DVDs, related to rows 2, 6, 7, 8, is significant**.** Mean±SD of the knowledge of the students in the new method changed from 6.1±2.6 at the beginning of the semester to 13.9±3.3 at the end (P<0.0005), while in the traditional method it

changed from 7.8±2.6 to 11.0±3.5 (P<0.005). The post-test mean of the knowledge of the P.G., was significantly higher in the intervention group compared to the control group (13.9±3.3 vs. 11.0±3.5) (P<0.006). The mean±SD of the attitude of the students in the new method changed from 15.9±2.2 to 16.2±2.6, without significant differences; similarly, in the traditional method it was found to be 15.6± 2.6 before and 15.6±2.9 after intervention. The post-test results of the attitude index indicate that there were no significant differences in the intervention group compared to the control group (16.2±2.6 vs. 15.6±2.9). The mean±SD of the awareness indicator among the P.G. in the new method, before starting the semester, was found to be 22.1±4.0, and at the end of the semester it was found to be 30.3±4.8, which are significantly different (P < 0.0005), indicating the effectiveness of the new method. The mean of the awareness index did not show any significant differences before and after intervention in the traditional group (23.4±4.3 vs. 26.6±3.6). The post-test mean of the index shows significant differences between the intervention group and the control group (30.3±4.8 vs. 26.6±3.6) (P<0.05).

Table 4. The mean (SD) of the questions to which the postgraduate students responded according to the method of training before and after intervention - Shahid Beheshti University of Medical Sciences, 2012

	Question		**New Method Mean(SD)**	**Traditional Method Mean(SD)**	**Sig**
1	I (as a paramedical postgraduate student) like to learn more statistics.	Pre-test	4.1(0.8)	3.7(1.7)	**0.55**
		Post-test	3.8(1.1)	3.8(0.9)	**0.9**
	Sig		0.31	0.97	
2	I understand almost all the statistical phrases in the journals.	Pre-test	2.0(0.8)	2.4(0.7)	**0.14**
		Post-test	3.0(1.0)	2.6(0.7)	**0.30**
	Sig		0.0005	0.44	
3	In medical research, I think knowledge of statistics is not required.	Pre-test	1.6(1.2)	1.4(0.7)	**0.68**
		Post-test	1.6(1.2)	1.6(1.1)	**0.92**
	Sig		0.92	0.68	
4	I generally feel I have to use statistics to reach a medical decision.	Pre-test	3.1(1.1)	2.8(0.8)	**0.43**
		Post-test	3.5(1.1)	3.1(1.4)	**0.43**
	Sig		0.17	0.55	
5	As an intelligent reader of medical references, it is required to know statistics to some extent.	Pre-test	4.3(1.0)	4.4(0.7)	**0.82**
		Post-test	4.5(0.6)	4.4(0.7)	**0.59**
	Sig		0.26	0.97	
6	I understand the interpretation of p-value as mentioned in medical studies.	Pre-test	1.3(0.7)	1.4(0.8)	**0.54**
		Post-test	4.0(1.1)	2.9(1.4)	**0.04**
	Sig		0.0005	0.02	
7	I can interpret the statistical results of medical studies.	Pre-test	1.5(1.0)	2.0(1.0)	**0.16**
		Post-test	3.7(0.8)	3.0(1.1)	**0.1**
	Sig		0.0005	0.05	
8	I can suggest an appropriate statistical method in order to answer the research questions.	Pre-test	1.4(0.8)	2.0(1.0)	**0.05**
		Post-test	3.3(1.0)	2.5(1.1)	**0.03**
	Sig		0.0005	0.31	
	Knowledge Index	Pre-test	6.1(2.6)	7.8(2.6)	**0.03**
		Post-test	13.9(3.3)	11.0(3.5)	**0.006**

Sig		0.0005	0.05	
Attitude Index	Pre-test	15.9(2.2)	15.6(2.6)	**0.8**
	Post-test	16.2(2.6)	15.6(2.9)	**0.5**
Sig		0.5	0.9	
Awareness Index	Pre-test	22.1(4.0)	23.4(4.3)	**0.57**
	Post-test	30.3(4.8)	26.6(3.6)	**0.05**
Sig		0.0005	0.13	

The mean of the knowledge index before intervention among medical students varied from 8 to 9 (out of 20), and after intervention it increased to 11-12. This was in range 6 to 8 in the postgraduate group before intervention, and increased to range 11 to 14 after intervention. The mean of the attitude index among medical students was in range 12-14 (out of 20) before and after intervention, while among postgraduates it was in range 15-16.

Analysis with respect to sex showed that there are no statistically significant differences between males and females, either in the medical or the P.G. group.

3.3 Participant Flow

A total number of 140 medical students (half of them in the intervention group) and 52 paramedical postgraduate students (41 of them in the intervention group) were recruited to the study in the primary phase of analysis. The response rate was 95%. Since completing the course was compulsory for the students, all of the participants completed the study. The final measurement was planned to be done at the last session of the semester, while some of the students, due to preparation for final exams, couldn't attend the last session and inevitably didn't respond to the questionnaire. At the end, 40 medical students and 20 postgraduates showed up for the final measurement. It is assumed that attrition was at random.

4. Discussion

A comparison of the two groups shows that the new methods effectively enhanced the awareness index of the students**.** The new method of teaching significantly upgraded the knowledge of the students in both groups. This finding complies with Sami (2010), who believes that medical students' understanding of biostatistics is deficient, while this can easily be changed by using interactive teaching techniques (Sami, 2010). In addition, it complies with Chance, who has shown that educational technology is an effective factor in teaching statistics (Chance et al., 2007).

The results of the study totally comply with the findings of other studies that show that medical students' and physicians' understanding of biostatistics is very low (Akinsola et al., 2014; Ghajarzadeh et al., 2011; Maha & Tantawi, 2009, West & Ficalora, 2007). This is unlike the findings, which stated that the level of knowledge of postgraduate medical students was moderate (Wadhwa, Kalyan, & Kalantharakath, 2015; Gore et al., 2012). It can be concluded situations are not same in every universities.

The attitude of postgraduates toward biostatistics at the beginning of the study was found to be positive; this finding conforms to Wadhwa et al., 2015 and Gore et al., 2012, in which it is stated that the attitude of postgraduate medical students was highly positive (Wadhwa et al., 2015; Gore et al., 2012). The positive attitude of postgraduates can be attributed to their previous familiarity with biostatistics, as well as the fact that the postgraduates were currently involved in research for their thesis.

Although the traditional method has been able to upgrade the level of knowledge of the medical students to some extent, it significantly made their attitude less positive. On the contrary, a significant incremental change of attitude of medical students toward biostatistics has been observed in the new method. As it is seen in Question 5, in the traditional method, "As an intelligent reader of medical references, it is required to know statistics to some extent," the average dropped from 4.1 to 3.2, before and after intervention, These findings comply with Clayden (1990), who believes theoretical courses risk losing contact with medical students, who come to medical school to become doctors, not statisticians. In some references, dry and tedious mathematical calculations are mentioned as problematic reasons (Freeman et al., 2008).

Similar to the results of Gore et al. (2012) and Khan and Mumtaz (2009), sex was not identified as a factor in the knowledge or attitude of the students (Gore et al., 2012; Khan & Mumtaz, 2009).

Comparing the two intervention groups, namely, medical and paramedical postgraduate students, in terms of the awareness index before and after intervention, (which changed from 21.9 to 26.6 in the medical group, and from 22.1 to 30.3 in postgraduates), can be indicative of the usefulness of instructional DVDs.

The biostatistics curricula for medical and paramedical postgraduate groups contain descriptive and analytical statistics. In the traditional method, the instructor is faced with many difficulties while employing complicated mathematical formulae. In the new method, however, using statistical software helps the instructor and students to solve exercises precisely and in a timely manner, and greater attention is given to the interpretation of results. Consequently, the introduced techniques help medical sciences students to enhance their knowledge and attitude, and their ability to interpret and understand the contents of statistics. It is recommended that the curricula of biostatistics in medical schools be designed based on the application of a computer and software.

For further studies, it is suggested that obstacles to the implementation of the proposed method be investigated. The traditional method relies only on the teacher, while a computer-designed education needs a high degree of collaboration between the staff of the computer section, technical section, and the trainer.

The limitation of this study is that the lecturers of the traditional method were two faculty members of biostatistics. It was assumed that there were no significant differences between their teaching methods.

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Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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