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The Mediating Role of Statistical Anxiety in the Relationship Between Statistical Attitudes and Statistical Self-Efficacy Beliefs of Students Taking Biostatistics Courses: A Path Analysis

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Abstract

Objective

In this study, the mediating relationship among statistical self-efficacy beliefs, statistical anxiety, and statistical attitudes of students taking biostatistics courses was examined. The population of our study consisted of undergraduate, graduate, and doctoral students taking biostatistics courses.

Material and Method

The study population comprised a total of 85 students, with 51 at the undergraduate level and 34 at the graduate and doctoral levels. Data for our study were collected at three different stages before the course (Pre), in the 8th week of the course (Intra), and at the end of the course (Post). The participation rates were as follows: Pre-course: 74 (87%), Intra-course: 59 (69%), and Post-course: 62 (73%). The "Statistical Self-Efficacy Belief Scale," "Statistical Anxiety Scale," and "Statistical Attitude Scale" were used to collect data in the research. The mediating role between statistical self-efficacy beliefs, statistical anxiety, and statistical attitudes was analyzed using the regression-based Bootstrapping technique.

Results

Analysis results showed that statistical anxiety had a mediating effect on the relationship between statistical attitudes and statistical self-efficacy beliefs before the course (p=0.013). At the 8th week of the course, a mediating effect of statistical anxiety was found in the relationship between statistical attitudes and self-efficacy beliefs (p=0.033). At the end of the course, no mediating effect of statistical anxiety was found in the relationship between statistical attitudes and self-efficacy beliefs (p=0.298).

Conclusion

Our study demonstrated that during the biostatistics course, statistical anxiety had a mediating effect on the relationship between statistical attitudes and statistical self-efficacy beliefs at the beginning and during the course; however, this effect disappeared at the end of the course. As a result of the research, the mediating role among statistical self-efficacy beliefs, statistical anxiety, and statistical attitudes of students taking biostatistics courses was found to be significant.

Keywords: Biostatistics, Anxiety, Attitude, Self-efficacy

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Introduction

Statistics is a mathematics-based science that interprets data collected to measure both quantitative and qualitative variables by reporting them through graphs or tables. Statistical science, a foundational field including areas like data mining, econometrics, actuarial science, and biostatistics, encompasses common research methods used in positive sciences, including economics, medicine, sociology, and engineering (1). To address the growing need for statistical science in many fields, including social sciences and health sciences, statistics has increasingly been integrated into the curricula of undergraduate and associate degree programs. During statistical education, performing statistical calculations directly related to mathematics and interpretation of the obtained results may lead to anxiety among students (2).

Statistical anxiety is not derived from the complexity of methods used for statistical analyses, but rather stems from attitudinal factors. It is a situational type of anxiety that emerges when dealing with statistics, observed while performing tasks such as data collection, data analysis, and interpretation of analysis results. Although related to mathematics, it is distinct from mathematical anxiety (3, 4). Factors leading to statistical anxiety in students are grouped under three main categories: 1. Personal factors consist of psychological and emotional attitudes and behaviors (perception, self-esteem, learning styles, and general anxiety level). 2. Situational factors are directly related to the course (the instructor's teaching style and terminology used in class, the pace of the course). 3. Environmental factors refer to individual-specific situations (gender, age, academic department, experiences in mathematics courses) (5).

Attitude, defined as the tendency to react positively or negatively towards an object, person, institution, or event, refers to an individual's willingness to adopt or reject the statistical learning process when it comes to statistics (6). It has been determined that students' negative attitudes towards statistics courses increase statistical anxiety (7). For students with high levels of statistical anxiety, this situation is considered a factor that negatively affects academic achievement (8). Self-efficacy belief plays a role in statistical learning as it affects a student's perception of their capacity to understand and complete statistical tasks (9).

In the literature, studies are extending from the past to the present that use different scales to determine students' levels of statistical anxiety and attitude (12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 5). These studies have revealed that negative attitudes towards statistics, statistical anxiety, and low levels of statistical self-efficacy affect students' well-being and overall academic performance. There is a limited number of studies investigating statistical anxiety, attitudes, or statistical self-efficacy. To increase the knowledge base in this field, it is crucial to investigate more deeply the interaction between statistical anxiety, attitudes, and self-efficacy (23).

In the health sector, statistics hold great importance in research planning, implementation, conducting statistical analyses, interpreting results, and preparing quality scientific publications (10). Due to the need for biostatistics in health sciences, it is extremely important to eliminate students' negative attitudes (11). Awareness of the opinions and attitudes related to the biostatistics course by instructors will help students participating in this course to better understand the content and engage with the course more positively (10).

The study aims to examine the mediating role of statistical anxiety in the relationship between statistical attitudes and statistical self-efficacy beliefs of students taking a biostatistics course. In addition, the scales to be used were applied to the students at different times during the biostatistics course to determine the relationships between them.

Material and Method

Data Collection Tools

In our study, the demographic data of the students was obtained. Additionally, scales were used to assess their status regarding the biostatistics course. In our study, the Statistical Self-Efficacy Belief Scale, the Statistical Anxiety Scale, and the Statistical Attitude Scale were used to determine the students' status towards the biostatistics course.

Statistical Self-Efficacy Belief Scale (SSEB)

The Statistical Self-Efficacy Belief Scale, developed by Finney and Schraw in 2003 and adapted to Turkish by Sevimli and Aydın (2017), is specifically developed for the Statistics course and used to evaluate the self-efficacy beliefs of students or instructors regarding this course (27, 28). The scale, which is prepared in a 6-point Likert-type format, consists of 14 items. The Cronbach's Alpha values of the scale in our study were calculated as Pre: 0.965, Intra: 0.935, and Post: 0.962.

Statistical Anxiety Scale (SAnx)

The Statistical Anxiety Scale, developed by Faber, Drexler, Stappert, and Eichhorn for graduate students,

was adapted to Turkish by Güler (2019) and consists of 17 items (29, 30). Statistical anxiety arises during the process of data collection, data analysis, and interpretation of analysis outputs. This anxiety affects the student's ability to understand articles, analyze data, and interpret the results. The Total Cronbach's Alpha values of the scale in our study were calculated as Pre: 0.920, Intra: 0.908, and Post: 0.945.

Statistical Attitude Scale (SAtt)
Robert and Bilderback (1980) developed a 34-item Statistical Attitude Scale and administered it to three groups of graduate students taking an introductory statistics course (12). Many studies have been conducted to measure statistical attitudes. One such study was developed by Köklü in 1994 (31). The statistical attitude scale developed by Köklü consists of 28 items. The scale was developed to reveal students' attitudes towards statistics. The Total Cronbach's Alpha values of the scale in our study were calculated as Pre: 0.897, Intra: 0.909, and Post: 0.935.

Study Design
The scales used to determine the students' status towards the biostatistics course were administered at three different time points. The biostatistics course was planned for 14 weeks.

The administration times of the scales:

Pre: Before the biostatistics course (Pre)

Intra: 8th week of the biostatistics course (Intra)

Post: Final week of the biostatistics course (Post)

The data were collected by administering the scales through a Google Form at the pre-, intra-, and post-test points.

Statistical Analysis
Sample Size
The population of our study consisted of undergraduate, master's, and doctoral students taking the biostatistics course. At the undergraduate level, there were 58 students, and at the master's and doctoral levels, there were 30 students, making a total population of 88 students. Our study aimed to reach the entire population. In our study, the participation rates were: Pre: 75 (85.2%), Intra: 59 (67.0%), and Post: 62 (70.4%) participants.

Statistical Analysis
The data is presented in terms of mean, standard deviation, median, minimum, maximum, percentage, and frequency. The normality of distribution for continuous variables was assessed using the Shapiro-Wilk test, Kolmogorov-Smirnov test, skewness, and kurtosis (with Lilliefors correction). For comparisons between quantitative variables, Pearson and Spearman correlation tests are used, depending on the normality of distribution. For comparisons between two independent groups, the Independent Samples t-test is used if the normality assumption is met, and the Mann-Whitney U test will be used if it is not. For comparisons of continuous variables among more than two independent groups, ANOVA is used if the normality assumption is met, and the Kruskal-Wallis test is used if it is not. Post-hoc tests after ANOVA used Tukey's test if the variances are homogeneous, and Tamhane's T2 test if they are not. For post-hoc tests after Kruskal-Wallis, the Kruskal-Wallis 1-way ANOVA (k samples) test is used. For comparisons of more than two dependent group variables, Repeated Measures ANOVA is used if the normality assumption is met, and the Friedman test is used if it is not. Post-hoc tests after Repeated Measures ANOVA used Tukey's test if the variances are homogeneous, and Tamhane's T2 test if they are not. For post-hoc tests after Friedman, the Friedman 2-way ANOVA by ranks (k samples) test is used. The significance of indirect effects in the model used to determine the relationships between the scales is tested using the structural equation modeling bootstrapping method. Multivariate normality was assessed using Mardia's test, which evaluates skewness and kurtosis and is widely used in SEM analyses. To address potential deviations from normality, bootstrapping with 1000 resamples was applied. The path coefficients (β) of the model were calculated. All analyses were performed using IBM SPSS 20 and JAMOVI 2.2.2 statistical software. Statistical significance set at $p<0.05$.

Results

The participants' mean age (±SD) was 23.7±3.09 years (21–36), and 83.0% were female. The descriptive statistics of the scores of the scales and the sociodemographic characteristics of the students are shown in Table 1.

In the comparison of gender and total scores of the scales, no statistically significant difference was found between the total scores of the scales between genders ($p>0.05$). When the education level of the participants was compared with the total scores of the scales, a statistically significant difference was found only between the total score of the Pre SAtt scale ($p=0.008$). There was no statistically significant difference between education level and other scale

Table 1 Sociodemographic characteristics of participants and descriptive statistics of the scores of the scales

		N	%
Gender	Female	73	83.00%
	Male	15	17.00%
Educational Level	Undergraduate Student	58	65.90%
	Master's Student	20	22.70%
	Doctoral Student	10	11.40%
		Mean ± SD	Median (Min-Max)
Pre SSEB (n=75)		33.76 ± 13.48	34 (14-68)
İntra SSEB (n=58)		45.81 ± 11.15	46.5 (27-82)
Post SSEB (n=62)		45.15 ± 12.91	43.5 (15-75)
Pre Satt (n=75)		80.31 ± 13.05	78 (50-110)
Intra SAtt (n=58)		83.64 ± 12.99	84 (57-111)
Post Satt (n=62)		81.52 ± 17.65	82 (24-118)
Pre Sanx (n=75)		32.73 ± 9.83	30 (18-68)
Intra SAnx (n=58)		29.36 ± 7.42	29 (17-46)
Post Sanx (n=62)		29.79 ± 9.10	28 (17-51)

Pre SSEB: Prior to The Statistical Self-Efficacy Belief Scale, Intra SSEB: Intra to The Statistical Self-Efficacy Belief Scale, Post SSEB: Post to The Statistical Self-Efficacy Belief Scale, Pre Satt: Prior to The Statistical Attitude Scale, Intra SAtt: Intra to The Statistical Attitude Scale, Post Satt: Post to The Statistical Attitude Scale, Pre Sanx: Prior to The Statistical Anxiety Scale, Intra SAnx: Intra to The Statistical Anxiety Scale, Post Sanx: Post to The Statistical Anxiety Scale

total scores (p>0.05). When the correlation of the total scores of the scales with age was analysed, it was found that there was a correlation only with the total score of the Pre-SHT scale (r=0.329; p=0.004). No statistically significant correlation was found between the other scale total scores and age (p>0.05) (Table 2).

The results in Table 3 showed the internal consistency levels for three different scales (SSEB, SAnx, and SAtt), and all of them showed high levels of reliability. For the Statistics Self-Efficacy Belief Scale, Cronbach's Alpha values and McDonald's Omega were very high in the pre-course (0.965 – 0.967), in-course (0.935 – 0.936), and post-course (0.962 – 0.964) measurements. This indicates that the scale reliably measures participants' self-efficacy beliefs. Similarly, Cronbach's Alpha values and McDonald's Omega values for the Statistics Anxiety Scale were also high in the pre-course (0.920 – 0.922), in-course (0.908 – 0.911), and post-course (0.945 – 0.948) measurements, indicating that the scale consistently assessed participants' anxiety tendencies. The Statistics Attitude Scale shows a similar reliability, providing reliable results with pre-course (0.897 – 0.904), intra-course (0.909 – 0.919), and post-course (0.935 – 0.945) values. In general, the high Cronbach's Alpha values obtained in all scales indicate that the internal consistency of these measurement tools and their consistency among the participants are high, and therefore the results are reliable and valid (Table 3). The results of the goodness of fit analysis of the CFA model for the scales used and the path model are presented in Table 4 (Table 4).

According to the results of Table 5, the analyses show that there are significant differences between the stages in statistical self-efficacy belief, anxiety, and attitude scales. In terms of statistical self-efficacy belief, there were significant differences between pre, intra, and post measurements (F=31.00, p<0.001). This shows that there was a significant increase in students' self-efficacy beliefs during the course. In the evaluation of the statistics anxiety scale, significant differences were found between the pre- and Intra measurements (F=3.23, p=0.045), indicating that there were improvements in anxiety levels. In the results of

Table 2 Comparisons of total scale scores with Age, Educational Level and Gender

Correlations (Age)									
	Pre_SSEB	İntra_SSEB	Post_SSEB	Pre_SAtt	Intra_SAtt	Post_SAtt	Pre_SAnx	Intra_SAnx	Post_SAnx
r	0.061	0.012	-0.017	0.329	0.244	0.094	-0.011	-0.22	-0.022
p	0.601	0.926	0.898	0.004	0.065	0.468	0.925	0.097	0.863
N	75	58	62	75	58	62	75	58	62
	Educational Level								
	Undergraduate Student		Master's Student		Doctoral Student				
	Mean ± std	Medyan (min-max)	Mean ± std	Medyan (min-max)	Mean ± std	Medyan (min-max)	H	p	
Pre_SSEB	33.6 ± 13.66	32.5 (14-68)	35.18 ± 14.45	35 (14-57)	31.75 ± 11.25	31.5 (14-48)	0.367	0.832	
Intra_SSEB	46.28 ± 11.74	48 (27-82)	43 ± 10.37	42 (28-66)	48.5 ± 5.51	49 (42-54)	1.695	0.429	
Post_SSEB	45.89 ± 13.15	43 (19-75)	44.36 ± 11.32	47 (26-57)	39.75 ± 17.44	44 (15-56)	0.053	0.974	
Pre_SAtt	77.14 ± 12.6	75 (50-110)	87.88 ± 11.54	87 (71-109)	84 ± 12.59	81.5 (72-109)	9.657	0.008	
Intra_SAtt	82.77 ± 12.94	84 (57-111)	83.36 ± 13.18	86 (66-107)	93.75 ± 11.76	89.5 (85-111)	2.551	0.279	
Post_SAtt	79.34 ± 18.85	78.5 (24-118)	86.5 ± 12.91	90.5 (60-104)	88 ± 16.69	86 (71-109)	2.241	0.326	
Pre_SAnx	31.8 ± 8.57	29 (19-56)	34 ± 11.81	34 (18-68)	35.88 ± 12.92	33 (20-63)	1.172	0.556	
Intra_SAnx	29.77 ± 7.49	29 (17-46)	28.73 ± 6.71	29 (17-42)	26.75 ± 9.91	25 (17-40)	0.741	0.69	
Post_SAnx	30.36 ± 8.73	28 (18-51)	30.57 ± 9.83	28.5 (20-51)	20.75 ± 7.5	17 (17-32)	4.822	0.09	
	Gender								
	Female		Male						
	Mean ± std	Medyan (min-max)	Mean ± std	Medyan (min-max)	t		p		
Pre_SSEB	32.7 ± 13.42	32.5 (14-68)	39.91 ± 12.68	42 (16-58)	-1.657		0.102		
İntra_SSEB	44.76 ± 10.84	46 (27-82)	53.43 ± 11.16	60 (41-66)	-1.977		0.053		
Post_SSEB	45.62 ± 12.77	43 (19-75)	42.33 ± 14.12	44 (15-60)	0.704		0.484		
Pre_SAtt	79.22 ± 12.4	78 (50-109)	86.64 ± 15.52	84 (68-110)	-1.766		0.082		
Intra_SAtt	83.37 ± 12.82	84 (57-111)	85.57 ± 15.11	79 (72-107)	-0.417		0.678		
Post_SAtt	79.91 ± 17.26	81 (24-112)	91 ± 17.93	93 (67-118)	-1.773		0.081		
Pre_SAnx	33.44 ± 10.07	30.5 (19-68)	28.64 ± 7.39	29 (18-40)	1.51		0.135		
Intra_SAnx	29.31 ± 7.6	28 (17-46)	29.71 ± 6.52	29 (17-37)	-0.133		0.895		
Post_SAnx	30.28 ± 8.89	28 (17-51)	26.89 ± 10.34	24 (17-51)	1.035		0.305		

Mean ± std = Mean ± standard deviation; Median (min–max) = Median and range; t = Independent samples t-test statistic; p = Significance level ($p < .05$ considered statistically significant); r = Pearson correlation coefficient; H = Kruskal-Wallis H test statistic; N = Sample size.

Table 3 Cronbach's Alpha Values and McDonald's Omega of the Scales

Cronbach's α – McDonald's ω			
	Statistics Self - Efficacy Belief Scale (Item=14)	**Statistical Anxiety Scale (Item=17)**	**Statistics Attitude Scale (Item=28)**
	Total	Total	Total
Pre	0.965 – 0.967	0.920 – 0.922	0.897 – 0.904
Intra	0.935 – 0.936	0.908 – 0.911	0.909 – 0.919
Post	0.962 – 0.964	0.945 – 0.948	0.935 – 0.945

Pre: Prior to the biostatistics course; Intra: 8th week of the biostatistics course; Post: Final week of the biostatistics course.

Table 4 Results of model fit indexes

		Fit Measures							Test for Exact Fit		
		CMIN/DF	CFI	TLI	SRMR	RMSEA	RMSEA 90% CI Lower	RMSEA 90% CI Upper	χ^2	df	p
Statistics Self - Efficacy Belief Scale (Item=14)	**Pre**	1.68	0.956	0.942	0.043	0.096	0.064	0.125	116	69	<.001
	Intra	2.09	0.874	0.833	0.078	0.135	0.104	0.167	144	69	<.001
	Post	1.94	0.923	0.899	0.049	0.124	0.092	0.155	134	69	<.001
Statistical Anxiety Scale (Item=17)	**Pre**	2.41	0.780	0.733	0.094	0.138	0.117	0.159	270	112	<.001
	Intra	1.63	0.836	0.800	0.082	0.104	0.076	0.130	183	112	<.001
	Post	1.40	0.931	0.917	0.058	0.080	0.048	0.109	157	112	0.003
Statistics Attitude Scale (Item=28)	**Pre**	1.95	0.651	0.613	0.119	0.113	0.100	0.126	664	341	<.001
	Intra	2.16	0.639	0.600	0.140	0.140	0.126	0.154	737	341	<.001
	Post	1.94	0.766	0.741	0.134	0.123	0.109	0.137	661	341	<.001
Path Model (Pre_SAtt ⇒Pre_ SAnx ⇒Pre_SSEB)	**Pre**	9.62	1.000	1.000	0.000	0.000	0.000	0.000	28.866	3	<.001
	Intra	13.53	1.000	1.000	0.000	0.000	0.000	0.000	40.575	3	<.001
	Post	15.09	1.000	1.000	0.000	0.000	0.000	0.000	45.274	3	<.001

CMIN/DF: Chi-square/degree of freedom; RMSEA: Root mean square of approximation; SRMR: Standardised root mean square residual; CFI: Comparative fit index

Table 5 Comparison between pre, intra and post measurements of the scales

		N	Mean ± SD	Median (Min-Max)	F	p	post-hoc
Statistics Self - Efficacy Belief Scale (Item=14)	Pre	75	33.8 ± 13.48	34 (14-68)	31.00	<0.001	Pre-Intra, Pre-Post
	İntra	58	45.8 ± 11.15	46.5 (27–82)			
	Post	62	45.1 ± 12.91	43.5 (15-75)			
Statistical Anxiety Scale (Item=17)	Pre	75	80.3 ± 13.05	78 (50-110)	3.23	0.045	Pre-Intra
	İntra	58	83.6 ± 12.99	84 (57-111)			
	Post	62	81.5 ± 17.65	82 (24-118)			
Statistics Attitude Scale (Item=28)	Pre	75	32.7 ± 9.83	30 (18-68)	3.31	0.042	Pre-Intra
	İntra	58	29.4 ± 7.42	29 (17-46)			
	Post	62	29.8 ± 9.10	28 (17-51)			

F: One Way ANOVA test, p: p-value

the statistics attitude scale, significant changes were observed between pre and Intra (F=3.31, p=0.042), but no significant changes were observed between Pre and Post the course. These results emphasize that an effective statistics education can have positive effects on student achievement, especially by strengthening self-efficacy beliefs, and the importance of structured support for anxiety and attitude management (Table 5).

According to the results of Table 6, the correlations between the variables were analyzed. When we look at the non-significant correlations, we observe that

Table 6 Correlation analysis of the scales

Correlation Matrix										
		Pre SSEB	**Intra SSEB**	**Post SSEB**	**Pre SAtt**	**Intra SAtt**	**Post SAtt**	**Pre SAnx**	**Intra SAnx**	**Post SAnx**
Pre SSEB	**r**	—								
	p	—								
Intra SSEB	**r**	**0.440**	—							
	p	0.001	—							
Post SSEB	**r**	0.109	**0.372**	—						
	p	0.440	0.015	—						
Pre SAtt	**r**	**0.275**	0.245	**0.272**	—					
	p	0.017	0.083	0.051	—					
Intra SAtt	**r**	**0.287**	**0.402**	0.235	**0.618**	—				
	p	0.041	0.002	0.134	<.001	—				
Post SAtt	**r**	0.163	0.266	**0.484**	**0.441**	**0.621**	—			
	p	0.247	0.089	<.001	0.001	<.001	—			
Pre SAnx	**r**	**-0.433**	**-0.457**	-0.042	**-0.384**	**-0.438**	0.030	—		
	p	<.001	<.001	0.768	<.001	0.001	0.835	—		
Intra SAnx	**r**	**-0.406**	**-0.452**	**-0.320**	**-0.642**	**-0.594**	**-0.419**	**0.512**	—	
	p	0.003	<.001	0.039	<.001	<.001	0.006	<.001	—	
Post SAnx	**r**	-0.114	**-0.387**	**-0.368**	-0.238	**-0.299**	**-0.560**	0.193	**0.493**	—
	p	0.421	0.011	0.003	0.090	0.054	<.001	0.171	<.001	—

r: Spearman's Correlation Coefficient, p: p-value.

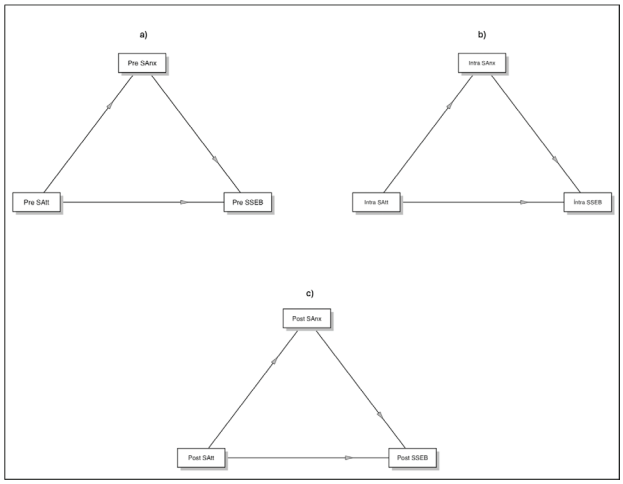

Figure 1
Path models
a): Mediation model of the prior of the biostatistics course, b): Mediation model of the 8th week of the biostatistics course, c): Mediation model of the final week of the biostatistics course.

Table 7 Mediation models results

Time	Type	Effect	Estimate	SE	95% C.I. Lower	95% C.I. Upper	β	z	p
Pre	Indirect	Pre_SAtt ⇒ Pre_SAnx ⇒Pre_ SSEB	0.152	0.0613	0.0323	0.272	0.148	2.49	0.013
	Component	Pre_SAtt ⇒ Pre_SAnx ⇒Pre_ SSEB	-0.289	0.0803	-0.4466	-0.132	-0.384	-3.6	< .001
		Pre_SAnx⇒ Pre_SSEB	-0.527	0.1533	-0.8272	-0.226	-0.384	-3.44	< .001
	Direct	Pre_SAtt ⇒ Pre_ SSEB	0.132	0.1154	-0.0942	0.358	0.128	1.14	0.253
	Total	Pre_SAtt ⇒ Pre_ SSEB	0.284	0.1154	0.0582	0.511	0.275	2.46	0.014
Intra	Indirect	Intra_SAtt ⇒ Intra_SAnx ⇒ Intra_SSEB	0.168	0.0789	0.0134	0.3226	0.196	2.13	0.033
	Component	Intra_SAtt ⇒ Intra_SAnx ⇒ Intra_SSEB	-0.34	0.0603	-0.4579	-0.2214	-0.594	-5.63	< .001
		Intra_SAnx ⇒ Intra_SSEB	-0.495	0.2149	-0.9159	-0.0734	-0.329	-2.3	0.021
	Direct	Intra_SAtt ⇒ Intra_SSEB	0.177	0.1228	-0.0638	0.4176	0.206	1.44	0.15
	Total	Intra_SAtt ⇒ Intra_SSEB	0.345	0.1041	0.1409	0.5489	0.402	3.31	< .001
Post	Indirect	Post_SAtt ⇒ Post_SAnx ⇒ Post_SSEB	0.0578	0.0555	-0.051	0.167	0.0791	1.04	0.298
	Component	Post_SAtt ⇒ Post_SAnx	-0.2888	0.0542	-0.395	-0.182	-0.5602	-5.32	< .001
		Post_SAnx ⇒ Post_SSEB	-0.2003	0.1886	-0.57	0.169	-0.1413	-1.06	0.288
	Direct	Post_SAtt ⇒ Post_SSEB	0.2956	0.0972	0.1051	0.486	0.4044	3.04	0.002
	Total	Post_SAtt ⇒ Post_SSEB	0.3535	0.0819	0.1929	0.514	0.4835	4.31	< .001

SE: Standard Error, 95% C.I. Lower: 95% Confidence Interval Lower Bound, 95% C.I. Upper: 95% Confidence Interval Upper Bound, β: Beta coefficient, Z: Z-score, p: p-value, Pre SSEB: Prior to The Statistical Self-Efficacy Belief Scale, Intra SSEB: Intra to The Statistical Self-Efficacy Belief Scale, Post SSEB: Post to The Statistical Self-Efficacy Belief Scale, Pre Satt: Prior to The Statistical Attitude Scale, Intra SAtt: Intra to The Statistical Attitude Scale, Post Satt: Post to The Statistical Attitude Scale, Pre Sanx: Prior to The Statistical Anxiety Scale, Intra SAnx: Intra to The Statistical Anxiety Scale, Post Sanx: Post to The Statistical Anxiety Scale.

there is no statistically significant relationship between Intra SSEB and Pre SAtt (p=0.297), Pre SSEB and Post SAtt (p=0.372), and Pre SAtt and Post SAtt (p = 0.913). On the other hand, the variable pair with the highest significance among the relationships was Intra SAnx and Intra SAtt (r=-0.618, p<0.01), showing a strong inverse correlation between these two variables. The relationship with the lowest significance was found between Post SSEB and Intra SSEB (r=0.203, p=0.01), and this relationship was found to

be a weak but significant correlation in the positive direction (Table 6).

The aim of the study was to examine the mediating role of statistical anxiety in the relationship between statistical attitudes and statistical self-efficacy beliefs of students taking biostatistics courses. Therefore, a theoretical framework was developed as shown in Figure 1.

According to Table 7, as a result of the bootstrapping analysis performed with the data obtained before the course, it is understood that the indirect effects in the model are statistically significant. Statistical anxiety mediates the relationship between statistical attitude and statistical self-efficacy beliefs (p=0.013). This effect was estimated as 0.152, indicating that statistical attitude has a significant indirect effect on Statistical self-efficacy beliefs through statistical anxiety. Looking at the percentages of explanatory power within the model, there is a significant negative relationship between statistical attitude and statistical anxiety (β = -0.384, p < 0.001). Similarly, there is a significant negative relationship between statistical anxiety and statistical self-efficacy beliefs (β = -0.384, p < 0.001). The direct effect of statistical attitude on statistical self-efficacy beliefs is not statistically significant (β = 0.128, p = 0.253), but the total effect is significant (β = 0.275, p = 0.014). These findings suggest that the total effect of statistical attitude on statistical self-efficacy beliefs is strengthened through the path mediated by statistical anxiety. There are no differential mediation effects across the other conditions (Table 7).

As a result of the bootstrapping analysis conducted in the 8th week of the course, it is seen that the indirect effects in the model are statistically significant. Intra-anxiety scale has a mediating effect on the relationship between statistical attitude and statistical self-efficacy beliefs (p=0.033), and this effect was estimated as 0.168. This shows that statistical attitude has a significant indirect effect on statistical self-efficacy beliefs through statistical anxiety. When the explanatory percentages in the model are analyzed, it is seen that there is a statistically significant negative relationship between statistical attitude and statistical anxiety (β = -0.594, p < 0.001). There is also a significant negative relationship between statistical anxiety and statistical self-efficacy beliefs (β=-0.329, p=0.021). The direct effect of statistical attitude on statistical self-efficacy beliefs was not statistically significant (β=0.206, p=0.15), but the total effect was significant (β=0.402, p<0.001). These findings suggest that the total effect of statistical attitude on statistical self-efficacy beliefs is strengthened through the mediated path of statistical anxiety. There were no different mediation effects in the relationships between the other variables (Table 7).

As a result of the bootstrapping analysis conducted with the data obtained after the course, the statistical significance levels of the indirect effects in the model were evaluated. The mediating effect of statistical anxiety in the relationship between statistical attitude and statistical self-efficacy beliefs was not statistically significant (p=0.298), and the effect was estimated as 0.0578. This shows that the mediating role of statistical anxiety is weak. When the explanatory percentages in the model are analyzed, it is seen that there is a significant negative relationship between statistical attitude and statistical anxiety (β=-0.5602, p<0.001), but there is no significant relationship between statistical anxiety and statistical self-efficacy beliefs (β=-0.1413, p = 0.288). In contrast, the direct effect of statistical attitude on statistical self-efficacy beliefs was statistically significant (β=0.4044, p = 0.002), and the total effect was also significant (β=0.4835, p<0.001) (Table 7). These findings indicate that statistical anxiety does not mediate, but the direct and total effects of statistical attitude on statistical self-efficacy beliefs are significant. There are no mediating effects among other variables.

Discussion

The findings of the study comprehensively reveal how statistics education affects students' self-efficacy beliefs, anxiety levels, and attitudes. The high Cronbach's Alpha values obtained indicate that the internal consistency of the scales used is robust and provides reliable measurements across participants. The pre-course (0.965), intra-course (0.935), and post-course (0.962) values for the Statistics Self-Efficacy Scale and the pre-course (0.920), intra-course (0.908), and post-course (0.945) values for the Statistics Anxiety Scale emphasize the reliability both between the scales and over time. The Statistics Attitude Scale shows a similar reliability with pre-course (0.897), intra-course (0.909), and post-course (0.935) values.

In terms of self-efficacy, a significant increase was observed in students' self-efficacy beliefs during the course (F=31.00, p<0.001). This indicates that the information and experiences in the teaching process strengthened students' beliefs about their capacities. In terms of statistics anxiety, significant differences between pre- and intra-course measurements (F=3.23, p=0.045) indicate that an effective teaching strategy was effective in reducing anxiety. Attitudes

towards statistics changed between pre- and intra-course measurements (F=3.31, p=0.042), but there were no significant changes between intra- and post-course measurements, indicating the limits of the initial attitudinal improvements.

Mediation effects analysis reveals that statistical anxiety plays an important role in the relationship between statistical attitude and statistical self-efficacy beliefs. In the pre-course analysis, the mediating effect of statistical anxiety was found to be significant (p=0.013, effect=0.152); in the analysis at the 8th week of the course, this effect became more evident (p=0.033, effect=0.168). After the course, this mediating effect was not statistically significant (p=0.298). This suggests that anxiety should be managed effectively during the training.

As a result, while statistics education positively affects students' self-efficacy beliefs (β=0.275, p = 0.014), it is understood that anxiety levels need to be managed to sustain this effect. It is recommended that anxiety management and attitude development strategies be used together in the training process because the overall effect of statistical attitude on statistical self-efficacy beliefs is strengthened through the mediation of anxiety. Using these findings, educators can make instructional strategies more effective by further integrating student-centered approaches and psychological support systems. Such integrated approaches may have more positive outcomes on student achievement and educational effectiveness.

At the end of our study, it was found that statistical anxiety played a mediating role in the model between students' attitudes towards statistics and their statistical self-efficacy beliefs at the beginning and middle of the course, but did not play a mediating role in the model at the end of the course. Our result shows that statistical anxiety in students decreases over time, and students start to learn statistics. Similar results were found in the literature. While Akyüz and Topcu (2022) stated that attitude positively affected self-efficacy, Bourne et al. (2024) and Hernandez de la Hera et al. (2023) showed that statistical anxiety was negatively related to self-efficacy (32, 33, 34). Peiro-Signes et al. (2021) emphasised the reducing effect of self-confidence on anxiety (35). Amirgholami et al. (2023) supported the complexity of these relationships by addressing the mediating role of self-efficacy (36).

Limitation

Even though the study's conclusions offer significant insights, it is crucial to acknowledge several limitations. The sample used in this study was selected from a single university population, which presents limitations. As a result, care should be taken when interpreting the findings' generalizability.

It should be prepared without subheadings.

Conflict of Interest Statement

All authors have no conflicts of interest to declare.

Ethical Approval

Ethical approval was obtained from "Atatürk University Faculty of Medicine Clinical Research Ethics Committee" (date: 31/103/2022; number: B.30.2.ATA.0.01.00/244).

Consent to Participate and Publish

Written informed consent to participate and publish was obtained from all individual participants.

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Authors Contributions

KK: Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Validation; Visualization; Writing- original draft.

SG: Conceptualization; Formal analysis; Funding acquisition; Investigation; Methodology; Project administration; Resources; Supervision; Validation.

DÖE: Investigation; Resources; Supervision; Validation; Writing-original draft.

ŞB: Formal analysis; Investigation; Visualization; Writing-original draft.

DBD: Funding acquisition; Resources; Supervision; Writing-review & editing.

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