

## Video Conferencing from Crises and Disasters to Daily Life: Reviewing the Psychometric Properties of the Zoom Exhaustion & Fatigue Scale and Determining the Cut-off Score<sup>1</sup>

Kriz ve Afetlerden Gündelik Hayata Video Konferans: Zoom Tükenmişlik ve Yorgunluk Ölçeği'nin Psikometrik Özelliklerinin Gözden Geçirilmesi ve Kesme Puanının Belirlenmesi

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<sup>1</sup> Ethics committee approval was obtained with the permission of Ondokuz Mayıs University, Social and Human Sciences Ethics Committee, dated 25.06.2021, and numbered (Decision no: 2021-532).to carry out this research.

## Öz

Video konferans uygulamaları kriz ya da afet dönemlerinde işleyişi sürdürmek üzere birincil araç haline gelirken, olağan koşullarda da kullanım oranı giderek yaygınlaşmaktadır. Bu çalışmada Zoom Tükenmişlik ve Yorgunluk Ölçeği (ZTYÖ) Türkçe formunun psikometrik özelliklerinin incelenmesi ve zihinsel açıdan tükenmiş ve yorgun hissetme durumunu ayırt edebilmesine yönelik ölçekten eşik değer niteliğinde bir kesme puanının belirlenmesi amaçlanmaktadır. Çalışma 270 üniversite öğrencisi ile yürütülmüştür. Katılımcılara bilgi toplama formu, ZTYÖ ve Chalder Yorgunluk Ölçeği (CYÖ) uygulanmıştır. Doğrulayıcı faktör analizinde, ölçeğin özgün formundaki 5 faktörlü yapı sağlanmıştır. ZTYÖ puanları ile CYÖ puanları arasında anlamlı ilişkiler olduğu, ZTYÖ puanının CYÖ puanını yordadığı bulunmuştur. Video konferansa ilişkin değerlendirme, katılım sayısı, sağlığa yönelik şikayetler ve ZTYÖ puanları arasında ilişkilere ya da grup farklılıklarına yönelik anlamlı sonuçlar bulunmuştur. ROC analizi sonucunda, ZTYÖ ortalama kesme puanı 1.96 olarak bulunmuştur. Kesme puanına göre CYÖ toplam puanı, video konferansa katılım sayısı, algıladıkları yük ve alınan keyif farklılaşmıştır. Cronbach alfa katsayısı tüm ölçek için .95 iken alt boyutları için .87-.92 arasında değişmiştir. Sonuçlar, ZTYÖ Türkçe formunun dijitalleşme çağında artan video konferans kullanımının neden olduğu tükenmişlik ve yorgunluğu değerlendirebilen ve ayırt edebilen psikometrik açıdan yeterli bir ölçüm aracı olduğunu göstermektedir.

**Anahtar Kelimeler:** Zoom Tükenmişlik ve Yorgunluk Ölçeği, kesme puanı, psikometrik Özellikler, video konferans, dijital çağ.

## Abstract

Video conferencing solutions have become a primary tool to sustain general operations during crises or disasters, and their usage is increasingly widespread even under normal circumstances. This study aims to examine the psychometric properties of the Turkish version of the Zoom Exhaustion and Fatigue Scale (ZEFS) and obtain a cut-off score from the scale to distinguish the state of feeling mentally exhausted and fatigued. The study was conducted with 270 university students. Participants completed an information form, the ZEFS, and the Chalder Fatigue Scale (CFS). In confirmatory factor analysis, the 5-factor structure in the original form of the scale was achieved. Significant correlations were found between ZEFS and CFS scores; ZEFS scores significantly predicted CFS scores. Significant results were found among video conferencing evaluations, the number of video conferencing, health complaints, and ZEFS scores in terms of relationship or group differences. In the ROC analysis, the mean cut-off score was found to be 1.96. According to the cut-off score, total CFS score, number of video conferencing attendances, perceived burden, and enjoyment differed. Cronbach's alpha coefficient was .95 for the entire scale, ranging from .87 to .92 for its subscales. The results indicate that the Turkish version of ZEFS is a psychometrically adequate measurement tool for assessing and distinguishing exhaustion and fatigue caused by the increasing use of video conferencing in the digital age.

**Keywords:** Zoom Exhaustion & Fatigue Scale, cut-off score, psychometric properties, video conferencing, digital age.

## Introduction

Video conferencing applications, which have distinctively entered our lives with the pandemic (Knight et al., 2021), have been re-introduced to education after the Kahramanmaraş Earthquake due to the effects of the disaster throughout our country (Council of Higher Education, 2023). Although the use of videoconferences existed as an option before the pandemic period, online functioning was adopted after the pandemic (Fauville et al., 2023). The experiences during the pandemic and advancements in technology have influenced the digital workflow trend (Abi Raad and Odhabi 2021; Ng et al., 2021). Looking at the flow of the process, after the World Health Organization declared a pandemic for the Covid 19 virus (WHO, 2020), the precautions and practices taken to prevent the spread of the epidemic had clear reflections on daily life (Teodorovicz et al., 2021). With quarantine implemented around the world, most activities and events were conducted remotely online and schools, universities, workplaces closed (Chou et al., 2020; Knight et al., 2021). General functioning of daily life turned into an online platform (Burki, 2020; Knight et al., 2021). In this context, the need to benefit from technology increased (Tanis, 2020). Video conferencing platforms such as Zoom became one of the primary tools for businesses to work, students to continue their education or individuals to socialize (Amponsah, van Wyk and Kolugu, 2022; Cao, 2021; Kondrad, 2020).

The use of virtual communication platforms to continue education in our country has been observed not only during the pandemic period but also after earthquake disasters. While an earthquake with a magnitude of 7.7 occurred in Kahramanmaraş on February 6, 2023, a second earthquake with a magnitude of 7.6 (epicenter in Elbistan) occurred hours later in the region (AFAD, 2023b). The earthquake caused serious losses such as the death and injury of thousands of people, as well as the displacement of millions of people from their homes (AFAD, 2023a). In response to the sheltering conditions, social circumstances, and the need for sustainable education processes for earthquake victims, our country's universities transitioned to online education in the spring term of 2022-2023. (Council of Higher Education, 2023). The widespread use of video conferencing applications came to the fore again (Eltahy and Elhadary, 2023). The transition to online education after the earthquake was met with reactions from the instructors, students and their families (Telli Yamahato and Altun, 2023). Considering the results of studies conducted on university students, such as students experiencing difficulties in participating in online education (Inside Higher Ed, 2020), having low motivation (Means and Neisler, 2020), and their mental health being negatively affected (Pelucio et al., 2022; Şahin and Baz, 2021), the relevant reactions appear to be understandable.

While the frequency of the use of video conferencing applications is increasing every day, it seems that the trend of digitalization continues even after extraordinary conditions are over. It was stated that the number of people who attended meetings via Zoom at the end of 2019 was 10 million, and this figure reached 300 million in April 2020 (Iqbal, 2023; Morris, 2020). The World Economic Forum (2020) reported that Zoom application was downloaded 2.1, 4.3 and 27 million times in January, February and March, respectively, in 2020. On the other hand, the widespread use of video conferencing continued despite the decrease in pandemic conditions and restrictions (Avcı and Ülgen, 2022; Dean, 2022; Richter, 2021). Even after the crisis period of the pandemic, online activity continued to be preferred over face-to-face activities in institutions and organizations related to both education and workplaces (Abi Raad and Odhabi 2021; Telli and Altun, 2020). While there were 2.1 billion Zoom users in June 2021 (Clement, 2022), Zoom mobile application was downloaded approximately 23 million times in September 2021 (Dean, 2022). It has also been stated that Zoom has more than 300 million users and its usage rate has increased more than 30 times since 2019 (Georgiev, 2023). The increasing usage rates or the rapid transition to online platforms during disasters and crisis situations seem to have made it a necessity to investigate the psychosocial factors related to the use of video conferencing.

Parallel to this meteoric rise in the use of video conferencing applications, the concept of 'Zoom fatigue' has emerged (Wiederhold, 2020). It has been stated that this online transformation has its own set of challenges and brings different dynamics to interpersonal relationships. Interacting and maintaining relationships through video conferencing involve distinct cognitive demands and even require an additional cognitive effort, which is mentioned to lead to mental fatigue (Van der Linden and Eling, 2006; Wiederhold, 2020). People strive to provide various components of synchronization in communication, such as capturing voices, gestures, and facial expressions, and evaluating incoming reactions to determine whether they are understood or not. However, in an interaction where only faces are seen, while non-verbal cues are missed, various environmental cues are also lacking (Spicer, 2020). On the other hand, what is written in the chat box during the interview also creates a disruptive effect on the ongoing verbal communication, in other words, it distracts attention (Spicer, 2020; Wiederhold, 2020). In real-life physical interactions, various elements come into play through shifting attention, such as looking around, taking notes, observing the speaker, and being able to move around. Moreover, while doing all these, individuals do not see and/or examine themselves actively as in video conferencing (Bailenson, 2021). It is also known that in

the process of self-monitoring, self-focused attention increases, self-evaluation processes become more negative and sharper, and negative affect also increases (Canvin et al., 2016; Fejfar and Hoyle, 2000; Ingram et al. 1988; Vriends et al., 2017).

In addition, enlarged facial images and our own reflection where we look increase stress and anxiety while also creating a feeling of restlessness and discomfort (Bailenson, 2021; Reinach Wolf, 2020; Wiederhold, 2020). It has even been suggested that enlarged faces and focused eyes may be perceived as threatening, even if the person has the knowledge that they are safe, and this may increase stress hormones (Reinach Wolf, 2020; Wiederhold, 2020) by increasing physical arousal (Takac et al., 2019). An increase in self-focused attention and anxiety is associated with elevated cortisol levels (Denson et al., 2012). Moreover, self-monitoring and self-observation are also linked to heightened social anxiety (Canvin et al., 2016; Ingram et al., 1988; Seltzer-Eade, 2017; Vriends et al., 2017) and deterioration in performance (Liao et al., 2002). All the aforementioned variables increase the non-verbal mental load in communication and this overload is considered as a potential cause of fatigue (Bailenson, 2021; Fauville et al., 2023). In video conferencing interaction, our mind makes extra efforts to understand what is going on and to capture real-life interaction (Jiang, 2020; Spicer, 2020). Therefore, the potential negative effects of the increasing use of video conferencing applications in terms of mental, emotional and psychological processes seem to be inevitable.

Zoom Exhaustion & Fatigue Scale (ZEFS) was developed by Fauville et al. (2021) to understand and evaluate the fatigue and exhaustion caused by the use of video conferencing applications. In the standardization studies conducted in our country, methodological limitations such as being carried on a white-collar sample (Akduman, 2021), or not examining the properties related to convergent and predictive validity were encountered (Akduman, 2021; Ateş and Kanık, 2022). Moreover, in general adaptation studies conducted in our country (Akduman, 2021; Ateş and Kanık, 2022; Deniz et al., 2022), it can be seen that a cut-off point was not determined from the scale to distinguish between those who feel mentally exhausted and fatigued and those who do not. Increasing use of video conferencing in the age of digitalization and rapid shift to online platforms in times of crisis seem to raise the need to distinguish between individuals who feel exhausted and fatigued in relation to digital functioning and those who do not. It is thought that the determination of a cut-off score will enable the exploration of the psychosocial effects of the digitalization trend, especially on samples that have been affected by it, which will contribute to the detection of needs or the development of intervention methods. In this context, the present study aimed to review the validity and reliability of ZEFS and to obtain a cut-off score from the scale as a threshold value.

## 1. Method

### 1.1. Participants

The present study was conducted with university students who were continuing their undergraduate education and who had long-term online education experience (more than one year). Sample size was determined through power analysis. In the power analysis conducted with WebPower software, a margin of error of 5% was utilized, and the RMSEA value and degrees of freedom (df) obtained as a result of confirmatory factor analysis (CFA) in Fauville et al. (2021)'s study were used as reference values (RMSEA=0.076, sd=85). As a result of the power analysis, it has been observed that when working with 220 observations, a test power of 99.99% is reached. The data of the five participants who were determined with outliers were excluded from the study sample (See 2.4 Statistical Analysis). The final sample of the study consisted of 270 university students with ages ranging from 18 to 30 ( $M=22.31$ ,  $SD=4.30$ ), including 161 females (59.63%) and 109 males (40.37%). The sample size was increased to account for potential missing data. Volunteers from the Faculty of Arts and Sciences who were studying various subjects, including history, biology, philosophy, statistics, psychology, mathematics, and sociology, were selected for the study using convenience sampling.

### 1.2. Measures

Within the scope of the study, Information Collection Form, ZEFS and Chalder Fatigue Scale were applied to the volunteer participants.

#### 1.2.1. Information Collection Form (ICF)

An ICF was employed to assess the participants' sociodemographic characteristics, their frequency of using video conferencing applications, and their evaluations of video conferencing. Participants rated how much they enjoyed participating in videoconferencing in the ICF and assessed the level of burden associated with video conferencing using a five-point Likert-type rating (1=not at all, 5=very much). In addition, participants stated approximately how many video conferences they attended in a standard day, whether there was an increase in health complaints in the last year (yes/no), and whether they felt mentally exhausted (yes/no) related to online activities in the last year.

### 1.2.2. Zoom Exhaustion and Fatigue Scale (ZEFS)

ZEFS was developed by Fauville et al. (2021) to examine the level of exhaustion and fatigue that may occur in individuals due to video conference participation. The scale is a self-report scale which consists of 15 items and provides a five-point Likert type measurement (1= not at all/never, 5= extremely/always). ZEFS has five sub-dimensions as general fatigue (items 1-3), visual fatigue (items 4-6), social fatigue (items 7-9), motivational fatigue (items 10-12) and emotional fatigue (items 13-15), which were determined by the authors who developed the scale based on the literature and field knowledge. A five-factor structure was obtained (CFI=.97, TLI=.96, RMSEA=.065, SRMR=.032,  $\chi^2(85) = 1058$ ) in the CFA conducted by Fauville et al. (2021) for the construct validity of the scale. It was stated that the Cronbach Alpha coefficients of all sub-dimensions of the scale ranged between .82 and .90. It was shown that the scale met validity and reliability requirements. High scores indicate greater Zoom fatigue. In the current study, the validity and reliability properties of the scale have been presented in the result section.

### 1.2.3. Chalder Fatigue Scale (CFS)

CFS is a 14-item self-report scale developed by Chalder et al. (1993) to evaluate the fatigue felt by individuals. The revised final version of the scale with 11 items was created by Cella and Chalder (2010). CFS consists of 11 items that evaluate physical (items 1-7) and mental fatigue (items 8-11). The scale provides a four-point (0-3) Likert type measurement and the total score that can be obtained varies between 0-33. The adaptation study of CFS for the Turkish sample was carried out by Adın (2019), and it was shown to be a valid and reliable measurement tool. High scores indicate increased fatigue. In this study, reliability coefficients ranging from .75 to .89 were obtained for the whole scale and its subscales.

## 1.3. Procedures

Fauville and her team, who developed the scale, were contacted via e-mail (geraldine.fauville@gu.se) to carry out the validity and reliability study of ZEFS, and the necessary permission regarding the right to use was obtained (G. Fauville, personal communication, May 16, 2021). The Turkish translation process of the scale includes various stages. First, the scale was translated into Turkish by two linguists who were graduates of English Language and Literature and Philology. The English and Turkish forms were then examined by a Turkish faculty member clinical psychologist licensed by the American Psychological Association (APA) and another expert clinical psychologist working as a faculty member. Necessary arrangements were made on the Turkish forms with the relevant linguistics experts, faculty members, and research team, and the Turkish form was obtained.

Before starting the research, approval was obtained from the Social and Human Sciences Ethics Committee regarding the feasibility of the study (Decision no: 2021-532). The study was conducted in compliance with relevant approvals and ethical principles. While collecting the data, participants were provided with an informed consent form, emphasizing the voluntary nature of their participation. The applications were carried out online and the students did not receive any additional points for this participation. The order of application of ZEFS and CFS was changed in accordance with the balancing technique (two separate links with different orders).

## 1.4. Statistical Analysis

Statistical analyses related to CFA were conducted with Lisrel 8.80 (Linear Structural Relations) package program. For reliability analysis, the psych package in the R-Project (Rewelle, 2022) was utilized, and descriptive statistics, correlation analysis, Independent Groups t-Test, regression analysis, and Receiver Operating Characteristic (ROC) analysis were conducted using the IBM SPSS 23 (Statistical Package for the Social Sciences) package program. The margin of error was taken as 5% in the study.

Before starting the analysis, the data set was examined in terms of univariate outliers ( $-3.29 > z < 3.29$ ), and the data of five participants identified as outliers were excluded from the analysis. Parametric statistical analyses were then applied to the data, which showed a normal distribution based on Kurtosis and Skewness coefficients, Shapiro-Wilk normality test results, and histogram graphs.

A series of analyses were carried out to evaluate the validity and reliability of the Turkish version of ZEFS. The validity of ZEFS was examined within the scope of CFA, convergent and predictive validity. For convergent validity, CFS, which is thought to evaluate constructs related to ZEFS and has been shown to be valid and reliable, was used. The average scores of the sub-scales and overall scale were obtained for both scales, and the relationships between these scores were examined by using Pearson Product-Moment Correlation Analysis. For predictive validity, the relationships between the total score of ZEFS and participants' evaluations regarding videoconferencing usage and frequency reported in the ICF were examined. Pearson

product-moment correlation analysis and linear regression analysis were performed to assess these relationships. The differences between groups in various variables were examined using the Independent Groups t-Test to assess the validity of known groups. The discriminating power of the scale between those who feel mentally exhausted and fatigued and those who do not was examined by ROC analysis.

## 2. Results

### 2.1. Validity Results

CFA was applied to examine the factor structure of the scale. Figure 1 shows the graph of the CFA results. The path coefficients of all items in the dimensions of general fatigue, visual fatigue, social fatigue, motivational fatigue and emotional fatigue were statistically significant ( $p < .05$ ) and positive ( $B > 0$ ). Path coefficients and significance statistics for all items in the five sub-dimensions of the scale are also shown in Table 1. According to CFA results, goodness of fit values vary between good fit and acceptable fit ( $\chi^2 = 163.05$ ,  $df = 80$ ,  $\chi^2/df = 2.03$ ,  $S-RMR = .004$ ,  $RMSEA = .06$ ,  $GFI = .93$ ,  $CFI = .99$ ,  $AGFI = .89$ ,  $NNFI = .99$ ). Goodness of fit statistics indicate that the scale has an adequate level of fit in terms of construct validity (Hu and Bentler, 1999; Mulaik, 2009; Şimşek, 2009).

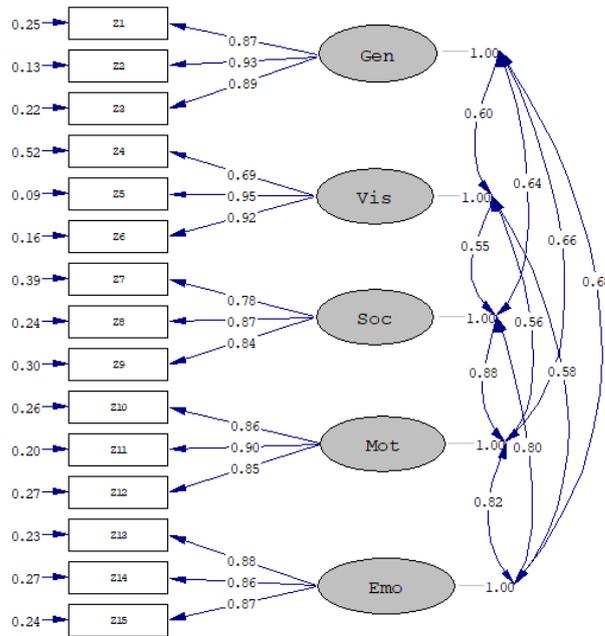
**Table 1.** The Results of CFA

Sub-dimensions	Item	L	$\Lambda$	t-value	p
Gen	z1	0.87	.87	17.64	
	z2	1.07	.93	19.94	<.001
	z3	0.98	.89	18.23	<.001
Vis	z4	0.77	.69	12.69	
	z5	1.12	.95	20.31	<.001
	z6	1.15	.92	19.10	<.001
Soc	z7	0.99	.78	14.86	
	z8	1.19	.87	17.60	<.001
	z9	1.05	.84	16.45	<.001
Mot	z10	1.07	.86	17.32	
	z11	1.11	.90	18.55	<.001
	z12	0.96	.85	17.13	<.001
Emo	z13	1.07	.88	17.86	
	z14	1.03	.86	17.12	<.001
	z15	1.08	.87	17.60	<.001

Note. L: Factor loading,  $\Lambda$ : Standardized factor loading, z: ZEFS items, GEN: ZEFS General Fatigue subscale, VIS: ZEFS Visual Fatigue subscale, SOC: ZEFS Social Fatigue subscale, MOT: ZEFS Motivational Fatigue subscale, EMO: ZEFS Emotional Fatigue subscale

The results of the correlation analysis for convergent validity and descriptive statistics of the scale dimensions are shown in Table 2. According to the results of the correlation analysis, there were significant positive correlations between the CFS and ZEFS scores, varying between .36 and .56 ( $p < .05$ ). The ZEFS total score significantly predicted the CFS total score ( $R^2 = .32$ ,  $F[1, 268] = 123.71$ ,  $p < .001$ ) and accounted for 32% of the variance in the CFS total score. These results supported the convergent validity of ZEFS.

The relationships between the number of videoconferencing, the burden felt during video conferences and the enjoyment derived from videoconference and the ZEFS scores were shown in Table 3. While there were positive and significant relationships between the number of video conferencing, the burden felt, and ZEFS scores (ranging from .31 to .57), there were also negative and significant relationships between the enjoyment of video conferencing and the ZEFS scores (ranging from -.20 to -.47). Additionally, ZEFS total score significantly predicted the number of videoconferencing ( $R^2 = .31$ ,  $F[1, 268] = 432.03$ ,  $p < .001$ ), the burden felt during video conferences ( $R^2 = .26$ ,  $F[1, 268] = 96.44$ ,  $p < .001$ ), and the enjoyment derived from video conferencing ( $R^2 = .17$ ,  $F[1, 268] = 55.92$ ,  $p < .001$ ). These findings supported the predictive validity of the scale.



**Figure 1:** Path Diagram of CFA

Note.  $\lambda$ : Standardized factor loading, z: ZEFS items, Gen: ZEFS General Fatigue subscale, Vis: ZEFS Visual Fatigue subscale, Soc: ZEFS Social Fatigue subscale, Mot: ZEFS Motivational Fatigue subscale, Emo: ZEFS Emotional Fatigue subscale

**Table 2.** Correlation Analysis Results for Convergent Validity and Descriptive Statistics

	1	2	3	4	5	6	7	8	9	M	SD
1 GEN	-									9.48	3.03
2 VIS	.57*	-								8.84	3.19
3 SOC	.58*	.52*	-							8.31	3.45
4 MOT	.60*	.52*	.80*	-						8.05	3.31
5 EMO	.63*	.55*	.73*	.75*	-					7.97	3.35
6 ZEFS-T	.80*	.75*	.87*	.88*	.88*	-				42.65	13.70
7 PF	.52*	.41*	.41*	.48	.52*	.56*	-			19.49	5.15
8 MF	.37*	.37*	.36*	.38*	.40*	.44*	.68*	-		9.97	2.53
9 CFS-T	.51*	.43*	.42*	.48*	.52*	.56*	.52*	.44*	-	2.68	0.65

Note. M=Mean, SD: Standard deviation, r: Correlation coefficient. GEN: ZEFS General Fatigue subscale, VIS: ZEFS Visual Fatigue subscale, SOC: ZEFS Social Fatigue subscale, MOT: ZEFS Motivational Fatigue subscale, EMO: ZEFS Emotional Fatigue subscale, ZEFS-T: ZEFS total score, PF: CFS Physical fatigue subscale, MF: CFS Mental fatigue subscale, CFS-T: CFS total score \*p<0.05

**Table 3.** Correlation Analysis Results Between Number of Attending Videoconferencing, Enjoying Video Conferencing and Burden Felt and ZEFS Scores

	GEN	VIS	SOC	MOT	EMO	ZEFS-T
Approximately how many video conferences do you attend in a standard day?	.51*	.43*	.42*	.48*	.52*	.56*
To what extent do you feel video conferences are a burden?	.57*	.31*	.39*	.41	.49	.51*
To what extent do you enjoy participating in video conferencing?	-.39*	-.20*	-.31*	-.38*	-.47*	-.41*

Note. GEN: ZEFS General Fatigue subscale, VIS: ZEFS Visual Fatigue subscale, SOC: ZEFS Social Fatigue subscale, MOT: ZEFS Motivational Fatigue subscale, EMO: ZEFS Emotional Fatigue subscale, ZEFS-T: ZEFS total score. \*p<0.05

The t-Test for Independent Groups was used to examine the difference in the total score of ZEFS between the participants who stated that they felt fatigued in relation to the online activities carried out for the last year and those who did not.

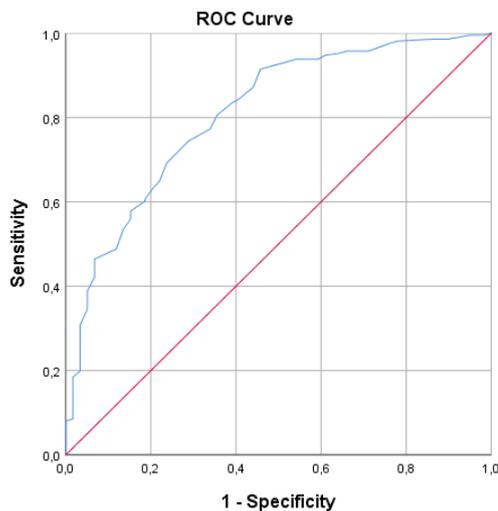
According to the results of the analysis, it was found that the participants who stated that they felt fatigued in relation to online activities ( $M=45.90$ ,  $SD=12.54$ ) had higher ZEFS total scores than those who stated that they did not ( $M=31.0$ ,  $SD=11.19$ );  $t(268)=8.24$ ,  $p<.001$ . On the other hand, t-Test for Independent Groups was conducted to examine the difference between the total scores of the participants who stated that their complaints about their health had increased in the last year and those who stated that they had not. ZEFS total scores of the participants who reported increasing health complaints in the last year ( $M=45.27$ ,  $SD=13.24$ ) were higher than those who did not ( $M=36.96$ ,  $SD=13.01$ );  $t(268)=4.81$ ,  $p<.001$ . It was also found that the participants who reported an increase in health complaints generally mentioned sleep problems, eye health problems such as blurred vision, musculoskeletal issues and pain (neck, back, head, etc.) problems. The analyses conducted on intergroup differences were considered to support the known-groups validity (Davidson, 2014) of the scale.

## 2.2. ROC Analysis Results on ZEFS's Discrimination of Mental Exhaustion and Fatigue

ROC analysis was conducted to determine a cut-off score, as a threshold value, for the ability of the ZEFS general score to distinguish between individuals who feel mentally exhausted and fatigued and those who did not. As a result of ROC analysis, Area Under the ROC Curve (AUC) was found as .809, sensitivity was found as .915 and specificity was found as .542. The AUC value is statistically significantly above 0.5 ( $p<.001$ ). Figure 2 shows the graph of ROC analysis curve.

Based on sensitivity and specificity scores, the mean cut-off score for feeling mentally exhausted and fatigued in relation to video conferencing attendance with ZEFS was found to be 1.96. According to this result, the level of Zoom fatigue significantly differs between participants who feel mentally exhausted and fatigued in relation to online activities or video conferencing attendance and those who do not.

In addition, when the cut-off point of ZEFS was taken as reference, significant difference was found between participants who felt exhausted and fatigued and those who did not in terms of total CFS score ( $t[268]=8.11$ ,  $p<.001$ ), the number of videoconference participation ( $t[268]=9.41$ ,  $p<.001$ ), perceived burden ( $t[268]=6.64$ ,  $p<.001$ ) and enjoying videoconferencing ( $t[268]=-4.72$ ,  $p<.001$ ) according to the t-Test result for Independent Groups. CFS total score, number of videoconference participation and perceived burden were higher in participants who felt exhausted and fatigued ( $M=31.46$ ,  $SD=6.40$ ;  $M=2.28$ ,  $SD=1.19$ ;  $M=3.36$ ,  $SD=1.12$ , respectively) compared to those who did not ( $M=24.47$ ,  $SD=6.37$ ;  $M=1.02$ ,  $SD=0.23$ ;  $2.34\pm 1.18$ , respectively). The level of enjoying video conferencing was lower for those who felt exhausted and fatigued ( $M=2.18$ ,  $SD=0.94$ ) than those who did not ( $M=2.78$ ,  $SD=0.92$ ). These findings supported that the scale could make good discrimination.



**Figure 2:** ROC Curve Sensitivity Specificity Values

## 2.3. Reliability Results

The results of the Cronbach Alpha reliability analysis conducted to examine the internal consistency of the ZEFS are shown in Table 4. When the Cronbach Alpha values (internal consistency coefficients) were examined, it was found that the general fatigue dimension had a reliability of .92, the visual fatigue dimension had a reliability of .88, the social fatigue dimension had a reliability of .87, the motivational fatigue dimension had a reliability of .90, and the emotional fatigue dimension had a reliability of .90. Item-total score correlations were found to range between .60 and .80. The overall Cronbach Alpha coefficient of the scale was found to be .95. When analyzed on an item basis, the corrected item correlation values of all

items of the scale are positive. It was also found that when item deleted, the reliability scores did not significantly increase from the current Cronbach Alpha values. Therefore, no item was deleted from the scale.

**Table 4.** Reliability Analysis Results

Sub-dimension	Item	Corrected item correlation	Alpha when item deleted	Alpha
GEN	z1	.86	.91	.92
	z2	.91	.87	
	z3	.88	.89	
VIS	z4	.69	.75	.88
	z5	.92	.65	
	z6	.90	.48	
SOC	z7	.72	.87	.87
	z8	.87	.76	
	z9	.83	.79	
MOT	z10	.84	.87	.90
	z11	.89	.83	
	z12	.83	.88	
EMO	z13	.83	.87	.90
	z14	.85	.86	
	z15	.87	.85	

Note. z: ZEFS items, GEN: ZEFS General Fatigue subscale, VIS: ZEFS Visual Fatigue subscale, SOC: ZEFS Social Fatigue subscale, MOT: ZEFS Motivational Fatigue subscale, EMO: ZEFS Emotional Fatigue subscale

## Discussion and Conclusion

The present study examined the validity and reliability features of the Turkish version of ZEFS and aimed to determine a cut-off score from the scale to distinguish between feeling mentally exhausted and fatigued. The validity of ZEFS was examined with CFA, convergent, predictive and known-groups validity. Additionally, the validity of the scale was supported by a series of analyses, such as the number of video conference sessions, evaluations regarding video conferencing participation, the relationships between ZEFS scores, and the differences between groups. As a result of the CFA, the five-factor structure in the original scale, namely general, social, emotional, visual and motivational fatigue, was also supported. It was found that the fit statistics varied between good fit and acceptable fit (Hu and Bentler, 1999; Mulaik, 2009; Şimşek, 2009). The factor loadings of the scale items were found to vary between .69 and .95. When the .30 lower limit of the items' scale representativeness is taken as reference (Stevens, 1992), it can be said that each item in the scale represents the scale at a good level. Thus, construct validity of the scale was supported.

In some Turkish standardization studies of ZEFS (Akduman, 2021; Ateş and Kanık, 2022), it has been noted that the relationship between ZEFS and a valid and reliable measurement instrument was not investigated. In this study, the validity of the scale was also examined with the convergent, predictive and known-groups validity method. Significant positive correlations at moderate and high levels were found between ZEFS and CFS scores, indicating that ZEFS demonstrated convergent validity. The ZEFS score significantly predicted the total CFS score, explaining 32% of the variance, thus demonstrating predictive validity. It was found that as the number of video conferencing sessions attended and the perceived burden in these sessions increased, the score of exhaustion and fatigue also rose. Conversely, as the level of enjoyment in video conferences decreased, the level of exhaustion and fatigue increased. Furthermore, the ZEFS total score, as a significant predictor, explained 31% of the variance in the number of video conference participation, 26% of the burden felt during video conferencing, and 17% of the enjoyment derived from video conferencing. Participants who stated that they felt mentally fatigued about participating in video conference had a higher ZEFS total score than those who did not. Participants who reported an increase in their health-related complaints in the last year were also found to have a higher total score on ZEFS than those who did not. The results as a whole provide evidence of the validity of the scale.

The primary goal and original aspect of the study is the determination of a threshold value for the scores obtained from the scale by ROC analysis. In standardization studies conducted by Akduman (2021), Ateş and Kanık (2022), and Deniz et al. (2022), analyses for determining the cut-off score were not found. In our study, ROC analysis was conducted, and the average cut-off score for ZEFS related to feeling mentally exhausted and fatigued due to video conference activities was found to be

1.96. It was found that the sensitivity and specificity values of the relevant cut-off score were sufficient to distinguish between those who felt exhausted and fatigued. In addition, the AUC was found to be .809. A large area under the ROC curve, in other words, an AUC value close to 1 indicates a good level of discrimination (Zou et al., 2007). This finding shows that the scale can distinguish between those who feel mentally exhausted and fatigued and those who do not.

On the other hand, considering the high total ZEFS scores of participants who reported feeling fatigued in relation to their participation in video conferences and those who reported an increase in health complaints over the past year, along with the significant relationships between the number of video conference participations, the burden felt during video conferences, and ZEFS scores overall, suggests the importance of establishing a cut-off value for assessing exhaustion and fatigue related to the frequency of using video conferencing. Indeed, when the cut-off score was taken as a reference, it was found that those who felt mentally exhausted and fatigued attended more video conferences, had a higher perceived burden, enjoyed video conferencing less, and had higher physical and mental fatigue according to the CFS total score. With the increasing trend of digitalization, the use of video conferencing in education and work settings is progressively rising, except during crisis and disaster periods (Ng et al., 2021). In recent years, the process of education has started to shift towards a combination of face-to-face education and distance learning (Abi Raad and Odhabi, 2021). Moreover, it is acknowledged that reduced activity and limited social interaction can have adverse effects on mental health (Pandya and Lodha, 2021; Snippe et al., 2016), highlighting the necessity of exploring the potential significant consequences of online trends themselves (Baker, 2021; Goldhaber et al., 2022). Therefore, having a cut-off score to examine the mental exhaustion and fatigue associated with increased use of video conferencing may improve functionality in assessments and practices.

Reliability coefficient's approaching 1 is accepted as an indicator of reliability (Tezbaşaran, 1996). Indeed, the reliability coefficient of the scale was .95 for the entire scale, and it varied between .87 and .92 for the subscales, ensuring reliability conditions. Examining the item-total score correlations reveals coefficients between .60 and .80, indicating a high level of functionality for all items. These results from the scale reliability analysis suggest that the ZEFS Turkish version is a reliable measurement tool.

Besides the important findings mentioned, the present study also has some limitations. In the current study, a test-retest study was not conducted to measure the reliability of the scale over time. The study was carried out only on university students, and data were collected from a single faculty which reflects another limitation. However, considering that education is conducted online during the pandemic period, or hybrid education applications are still in use, university students are seen as a critical study group. Given the potential negative effects of increasing digitalization on the young population (Halupa, 2016; OECD, 2018), it is essential to investigate the possible consequences of heightened online activity among university students.

The negative effects of increasing digitalization on mental health and subjective well-being are underlined by recent studies (Karakose et al., 2023; Limone and Toto, 2021; Pandya and Lodha, 2021), and even concepts such as digitalization anxiety (Pfaffinger et al., 2021) have started to be used. In the literature related to interaction via video conference, various cognitive and emotional variables, not present in face-to-face communication are emphasized. These include prolonged screen exposure, continuous self-monitoring (mirror anxiety), attempts to keep up with the flow, enlarged faces on the screen, anxiety, changing social demands, discomfort, and a sense of emptiness (Bailenson, 2021; Fejfar and Hoyle, 2000, Reinach Wolf, 2020, Spicer, 2020). In addition to the mentioned psychosocial factors, the health issues reported by the participants in the present study can also be considered as a physical reflection of Zoom fatigue because the participants have been receiving online education for over a year. Participants with increased health complaints also had higher ZEFS scores. It is widely known that screen time negatively affects physical health in various aspects (Borhany et al., 2018; Mishra and Mohapatra, 2018). Therefore, the reflections of the digital age on physical health and psychosocial functioning seem to be important areas that need to be evaluated in terms of well-being and addressed with preventive approaches.

In summary, the diverse biopsychosocial effects brought about by digitalization seem inevitable. Measurement tools to evaluate the potential negative effects of digitalization on general functioning will make it possible to study and explore these effects. Although distance learning or working has the flexibility to eliminate geographical boundaries, it seems important to study its potential disadvantages or outcomes in terms of determining needs, arranging practices and policies. Future studies examining the various effects of the current era of digitalization will be able to utilize the cut-off score to differentiate individuals experiencing mental exhaustion and fatigue, enabling comparisons between groups or specific investigations on affected samples from a clinical perspective. It is believed that conducting the mentioned studies will enable the multidisciplinary structuring of evaluations and interventions regarding the possible effects of increasing digitalization.

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### **Research and Publication Ethics Statement**

All ethical principles and rules were carefully observed in the collection, analysis, and reporting of data related to this research.

### **Author Contributions to the Article**

The authors have equally contributed to the study.

### **Conflict of Interest Statement**

There are no conflicts of interest in the preparation of this article.