Factors affecting female college students' intention to use digital technology in wearable devices to stimulate health monitoring

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ABSTRACT

In this study, we measured female college students' mental health and physical activities to identify factors that affect their intention to use wearable health-monitoring devices. Specifically, the study derived correlations between female students' health-related quality of life (HRQoL) including, physical activity, stress level, attitudes toward eating, and self-esteem. Using this information, we ascertained the relationship between female college students' use of wearable devices and physical activity and examined the requirements for smartphone applications for healthcare. We collected data from 308 female college students in the Republic of Korea over four months starting in July 2021 using an anonymous online survey. We then analyzed the data using descriptive statistics and linear regression. The results showed that the factors that caused stress in female college students during the past six months were fatigue, COVID-19, grades, worries about getting a full-time job, menstruation, and being overweight. This paper found a negative correlation between stress and self-esteem and a positive correlation between physical activity and self-esteem. People with experience using wearable devices reported a higher intensity in physical activity. More than half the participants recorded biometric information for their menstrual cycles and menstrual cramps regardless of whether they were using wearable devices. Currently, healthcare applications can suggest diets and track nutritional intake, menstrual cycles, and amount of exercise, which users want simultaneously. Therefore, there is a market demand for a mobile application linked with a wearable device and tailored for female college students that could combine and manage all these data. In the future, application developers should consider the needs of female college students.

1. Introduction

Attending college can be a stressful time for those in early adulthood. In addition to coping with academic pressures, some students may have to deal with the stressful task of separation and individualization from their family of origin. In this context, many college students are suffering from deteriorating mental health and have not yet formed health-related habits. There has been copious research on college students' mental and physical health [1–3]. The most common mental disorders for college students are anxiety and depression, and the leading causes of stress in college students are student debt, anxiety about the future, the pressures of studying,

living away from family, and environmental changes [4]. A research study reported that at least 40% of undergraduate students had experienced anxiety or depression above the average level and said they were stressed [5]. According to the American College Health Association survey, 35.1% of college students (24% of the male respondents and 39% of the female respondents) reported feeling nervous "most of the time" or "all the time" in the past 30 days [6].

As such, mental and physical health problems are very common among college students. In particular, female students are more vulnerable to mental and physical health problems than are males. A number of studies have found gender differences in the prevalence and severity of mental disorders and physical activity among college students [1,7,8]. The research found that female college students reported higher levels of anxiety than their male counterparts [9,10].

Debowska et al. surveyed 7228 university students from Poland (81% female), to examine gender differences in stress, depression, and anxiety among different groups of university students [11]. They found that female students scored significantly higher than male students on anxiety, depression, and stress.

Scholars have conducted extensive studies on the relationship between physical activity and mental health [12,13]. Moderate exercise was negatively associated with mental health problems, with a correlation between low activity levels and self-harm and suicidality [14]. Furthermore, women with low levels of physical activity were three times more likely to have high scores for self-reported depression than women who exercised almost every day [15]. Health behaviors and health status can directly impact female college students' sleep quality, stress levels, and life satisfaction [16]. Because regular physical activity positively affects physical and psychological health female college students' efforts to improve their physical condition should be encouraged and supported [17,18]. To explore female college students' mental health and physical activities, we adopted the HRQoL framework, a health-focused quality of life (QoL) concept that encompasses aspects of QoL that affect health such as function and physical and emotional health [19]. QoL reflects the perceived physical and mental health of an individual or group over a period of time [20]. Studies have demonstrated the importance of assessing the HRQoL of the student community [21,22]. It represents a group of people passing through critical stages in their lives [20].

Digital health technology has enabled the public to be more interested and participate in self-management and well-being. Wearable devices have increased citizens' participation in healthy lifestyles and well-being, enabling them to monitor and manage their own conditions independently. Combining mobile health and wearable devices, it is possible to effectively increase and maintain the facilitation of physical activity caused by wearable devices [18,23]. Digital health technologies such as wearable devices and mobile health encourage health-promoting behaviors by increasing physical activity and causing various changes in people's lifestyles [24]. According to Patel et al. wearable devices that stimulate users' motivation using feedback loops rather than just providing simple information can encourage the wearers to increase regular physical activity [25]. Furthermore, several studies have reported that digital health applications have become a popular way to track important health metrics, such as tracking apps that help users monitor their menstrual cycles and associated signs and symptoms [26,27]. In addition, digital health technology can be used to solve physical and mental problems [28,29]. Wearable devices may represent a possible solution for the health issues that these female college students face. Although many articles report that wearable devices can increase physical activity and support for those with mental problems [30], few studies have been conducted on female college students using wearable devices to improve their health. Furthermore, despite the wealth of studies on college students' mental and physical health and physical activity [31–33], more research is needed on how depression, anxiety, stress, self-esteem, and physical activity affect female college students. Many of the past studies have focused on comparing male and female students [7,34,35]. Few studies have focused exclusively on female students, despite evidence that women experience stressors unique to their gender and report higher anxiety levels than male students [36]. Any above-average degree of depression, anxiety, or stress can negatively affect self-esteem, and studies show that activity can help.

In this study, we examined female college students' health-related quality of life (HRQoL) and analyzed the correlations between satisfaction with college life, physical activity, stress level, eating attitudes, self-esteem, and use of wearable devices. Therefore, to identify factors that affect their mental health and physical activities and measure factors that affect female college students' intention to use wearable health-monitoring devices, we explore the following major research questions.

- What is the female college student's health-related quality of life, including attitudes toward eating, self-esteem, and physical activity?
- What are the factors affecting female college students' mental health?
- What are the factors that affect female college students' intention to use wearable health-monitoring devices?
- What is the correlation with the health-related quality of life that female college students are experiencing?

2. Research methods

This study uses a quantitative approach to explore the factors influencing female college students' intention to use wearable devices to promote health monitoring. We employed the survey method to determine female college students' health-related quality of life (HRQoL) as a measurement of the health status of individuals [37], including stress, attitudes toward eating, self-esteem, and physical activity, and the statistical relationships between them, the survey method was employed. An online self-report questionnaire to evaluate HRQoL and wearable device user experience was completed by 308 female college students. Informed consent was obtained from all participants in the study. The study protocol and procedures were approved by Sookmyung Women's University Institutional Review Board. Descriptive statistics were calculated and linear regression was performed using SPSS version 17. Linear regression was used to assess the relationship between stress, eating attitude, self-esteem, college life satisfaction, physical activity, and wearable device use. Participants were recruited between July 2021 and October 2021 to take part in an anonymous online survey. The survey

Table 1
Demographic and physical activity information of survey respondents.

Demographic Information	n (%)	Physical Activity Questions	n (%)
Age	44 (14.3)	*How much physical activity (walking, running, exercising) do you do per day?*	59 (19.28)
20 years old	52 (16.9)	Less than 15 min	93 (30.39)
21 years old	50 (16.2)	15 min - less than 30 min	94 (30.72)
22 years old	62 (20.1)	30 min - less than 1 h	48 (15.69)
23 years old	40 (13.0)	1 h - less than 2 h	12 (3.92)
24 years old	36 (11.7)	2 h - less than 3 h	0 (0.00)
25 years old	16 (5.3)	more than 3 h	81 (26.47)
26 years old	5 (1.6)	*What is your favorite type of physical activity?*	84 (27.45)
27 years old	3 (0.9)	Very light (e.g., sitting, studying, reading)	56 (18.30)
more than 28	70 (22.73)	Light (e.g., slow walking)	46 (15.03)
Year	58 (18.83)	Light plus (e.g., walking the stairs, cooking, shopping)	27 (8.82)
Freshman	72 (23.38)	Moderately vigorous (e.g., weight training, aerobic)	6 (1.96)
Sophomore	108 (35.06)	Moderately vigorous plus (e.g., tennis, swimming, jogging)	6 (1.96)
Junior	72 (23.38)	Vigorous (e.g., hiking, skiing, intensive running)	51 (16.67)
Senior	64 (20.78)	Others	72 (23.53)
Major	27 (8.77)	*What is your usual physical activity? **	232 (75.82)
Humanities	8 (2.60)	Go to gym for exercise	78 (25.49)
Social Science	57 (18.51)	Use stairs instead of elevators	114 (37.25)
Natural Science	18 (5.84)	Take a walk around town	42 (13.73)
Science	47 (15.26)	Jogging and running	69 (22.55)
Engineering	15 (4.87)	Home workout	73 (23.86)
Medical Science	134 (43.51)	Others	58 (18.95)
Arts and Physical Education	8 (2.60)	*If you don't normally do a lot of physical activity, what is the reason? **	29 (9.48)
Other	10 (3.25)	N/A (Doing a physical activity)	161 (52.61)
City of Residence	5 (1.62)	No spare time for exercise	70 (22.88)
Seoul	13 (4.22)	No suitable space for exercise	23 (7.52)
Busan	138 (44.81)	Can't find a reason to do	
Daejeon	21 (6.82)	Tired	
Daegu	130 (42.21)	Used to do exercise before COVID-19	
Kwangju	96 (31.17)	Others	
Other	58 (18.83)		
College Life Satisfaction	3 (0.97)		
Very satisfied			
Somewhat satisfied			
Neither satisfied nor dissatisfied			
Somewhat dissatisfied			
Very dissatisfied			

Note. * Multiple selection possible.

links were primarily posted on social sites that only female users could sign up for and on a social networking site (SNS). The 308 participants were all female college students currently attending universities in South Korea.

2.2. Survey procedure

The survey was administered online through the Survey Monkey platform using a secure anonymous URL. The survey included questions related to general demographic information, HRQoL (exercise information, level of stress, and eating attitude), self-esteem, and use experience with wearable devices. In the first question, to check the criteria for participation in the study, participants were asked if they were female college students currently attending a university. The stress questionnaire was adopted from the Perceived Stress Scale (PSS), which is a widely used psychological instrument for measuring perceived stress [38]. It measures the degree to which a person rates their life situations as stressful in the last month; all PSS questions were translated into Korean. Participants were also asked about factors that had been stressful for them in the past six months. The eating attitude questionnaire was based on the Eating Attitudes Test (EAT) translated into Korean. EAT is an extensively used self-report measure of eating disorder characteristics [39,40]. The self-esteem questionnaire was adopted from the modified Korean version [41] of Rosenberg's Self-Esteem Scale [42]. The physical activity questions were adapted from the International Physical Activity Questionnaire [43].

The first question related to wearable devices was whether the participants had used a wearable device before. Depending on the answer, the subsequent questions were different. For users of wearable devices, the questions were related to their experience with wearable devices, including usage period, used device brand, type of collected data, and reasons for sustained use, and their experience of using mobile apps to collect health information. For the nonusers, the questions inquired after the reasons they did not use the device and any health-related biometric data they collected through mobile apps.

Table 2
Responses to the stress questionnaire.

Questions	%	Questions	%
Have you been upset because of something that happened unexpectedly?	4.90	*Have you been able to control irritation in your life?*	2.11
Never	25.87	Never	15.79
Almost never	48.25	Almost never	35.79
Sometimes	15.38	Sometimes	39.65
Fairly often	5.59	Fairly often	6.67
Very often	4.55	Very often	7.02
Have you felt that you were unable to control the important things in	20.98	*Have you felt that you were on top of things?*	30.18
your life?	43.71	Never	41.05
Never	24.13	Almost never	16.14
Almost never	6.64	Sometimes	5.61
Sometimes	3.85	Fairly often	10.18
Fairly often	11.89	Very often	25.26
Very often	38.81	*Have you been angered because of things that were outside your control?*	37.19
Have you felt nervous and "stressed"?	31.82	Never	23.51
Never	13.64	Almost never	3.86
Almost never	1.75	Sometimes	8.07
Sometimes	25.17	Fairly often	29.12
Fairly often	40.21	Very often	34.39
Very often	27.62	*Have you felt difficulties were piling up so high that you could not overcome*	18.95
Have you felt confident about your ability to handle your personal	5.24	*them?*	9.47
problems?	1.75	Never	14.69
Never	18.25	Almost never	47.20
Sometimes	49.12	Sometimes	49.65
Fairly often	28.42	Fairly often	27.62
Very often	2.46	Very often	24.13
Have you felt that things were going your way?	4.56	*What do you think are the factors that have been stressful for you in the past*	9.09
Never	31.23	*6 months? ***	35.31
Almost never	40.35	Scholarships	23.43
Sometimes	20.35	Grade	55.94
Fairly often	3.51	Midterm and final exam	16.08
Very often		Relationship with friends	26.92
Have you found that you could not cope with all the things that you		Relationship with parents	33.92
had to do?		Relationship with siblings	52.10
Never		Menstruation	10.49
Almost never		Low level of activity	20.63
Sometimes		Fatigue and tiredness	24.83
Fairly often		Appearance	39.86
Very often		Skin, Acne	11.89
		Overweight	
		COVID-19	
		Apartment noise	
		Comparison with others via Social Network Site (SNS)	
		Part time job	
		Getting a full-time job	
		Others	

Note. * Multiple selection possible.

3. Results

3.1. Demographic information

The basic demographic background and physical activity information of the participants are shown in Table 1. Participants were predominantly 20–24 years old (80.5%), and attended freshmen (22.73%), sophomore (18.83%), junior (23.38%), and senior (35.06%) years. The majors of most respondents were in humanities (23.38%), social sciences (20.78%), or engineering (18.51%). The largest group of participants reported that they were somewhat satisfied (42.21%) with their college life, followed by somewhat dissatisfied (18.83%). For physical activity, the largest group of participants (30.72%) performed 30 min to 1 h of physical activity per day, followed by those who performed 15–30 min (30.39%). Female college students were likely to engage in very light (26.47%), light (27.45%), and light plus (18.30%) levels of physical activity. Most participants' physical activity in daily life was a walk around town (75.82%), followed by a home workout (37.25%).

3.1.1. Stress questionnaire

The stress questionnaire consisted of 10 questions asking participants' feelings and thoughts in the past in a certain way (e.g., "Have you felt nervous and stressed?", "Have you felt that you were unable to control the important things in your life?"). Each item was rated as 1 (never), 2 (almost never), 3 (sometimes), 4 (fairly often), or 5 (very often). To the question "Have you felt nervous and stressed?", the participants responded with sometimes (38.81%) fairly often (31.82%), and very often (13.64%) (see Table 2). Furthermore,

Table 3
Responses to the eating attitude questionnaire.

Question Items	%	Question Items	%
I'm terrified about being overweight	9.59	*I avoid foods high in carbohydrates (e.g., bread)*	40.96
Never	12.92	Never	31.37
Almost never	33.21	Almost never	15.87
Sometimes	25.09	Sometimes	8.86
Fairly often	19.9	Fairly often	2.95
Very often	32.10	Very often	33.21
I avoid eating when I'm hungry	32.10	*I feel very guilty after eating*	28.41
Never	28.04	Never	23.62
Almost never	5.54	Almost never	11.44
Sometimes	2.21	Sometimes	3.32
Fairly often	22.51	Fairly often	15.87
Very often	27.68	Very often	12.92
I find myself preoccupied with food	28.04	*I think a lot about wanting to be thinner*	28.78
Never	16.97	Never	24.35
Almost never	4.80	Almost never	18.08
Sometimes	32.84	Sometimes	31.37
Fairly often	24.35	Fairly often	20.66
Very often	31.37	Very often	22.14
I have gone on eating binges where I feel I may not be able to stop	9.59	*I think about burning up energy (calorie) content in foods that I eat*	17.71
Never	1.85	Never	8.12
Almost never	26.20	Almost never	18.45
Sometimes	31.00	Sometimes	15.87
Fairly often	22.88	Fairly often	28.04
Very often	16.97	Very often	20.66
I cut my food into small pieces	2.95	*I think a lot about having fat on my body*	16.97
Never	31.73	Never	64.21
Almost never	28.41	Almost never	14.39
Sometimes	21.77	Sometimes	11.81
Fairly often	15.13	Fairly often	8.12
Very often	2.95	Very often	1.48
I am aware of the calorie content of what I eat		*I eat diet foods for dieting*	25.46
Never		Never	17.71
Almost never		Almost never	30.26
Sometimes		Sometimes	16.24
Fairly often		Fairly often	10.33
Very often		Very often	
		I do exercise for losing weight	
		Never	
		Almost never	
		Sometimes	
		Fairly often	
		Very often	

respondents responded with sometimes (40.35%), fairly often (20.35%), and very often (3.51%) to the question "Have you found that you could not cope with all the things that you had to do?" The results indicate that female college students experience significant stress. Participants were also asked about the factors that had been stressful for them in the past six months. The results showed that the COVID-19 situation (52.10%), midterm and final exams (49.65%), final grades (47.20%), getting a full-time job (39.86%), menstruation (35.31%), and overweight (33.92%) have been stressors for them in the past six months. This is consistent with previous research findings that female college students experience more distress and lower self-esteem [44].

3.1.2. Eating attitude questionnaire

To complete the EAT, participants rated their agreement with statements about food and weight. The statements represent avoidance of high calorie food and an obsession with being thin. Examples include "I'm terrified about being overweight." and "I avoid foods high in carbohydrates." Participants rated their attitude using five possible options: never (1), almost never (2), sometimes (3), fairly often (4), and very often (5). A total score greater than 20 is considered a possible eating disorder problem, such as anorexia and bulimia (Lane et al., 2004; Maloney, 1988). A total of 44.99% participants responded fairly often and very often to the "I'm terrified about being overweight" statement (see Table 3). Furthermore, 42.43% participants responded fairly often and very often to "I think a lot about wanting to be thinner." The EAT survey showed that female college students were more likely to be obsessed with being thin. It is also consistent with previous research findings that female college students reported binge eating and inappropriate compensatory behaviors as a means for controlling weight and shape. Female students also felt under more pressure to attain the media physical appearance standard than males [45].

3.1.3. Self-esteem questionnaire

Participants completed the questionnaire by indicating their agreement with 10 question items (e.g., "On the whole, I'm satisfied

Table 4
Responses to the self-esteem questionnaire.

Question Items	%	Question Items	%
On the whole, I'm satisfied with myself	6.76	I certainly feel useless at times	17.79
Strongly disagree	27.05	Strongly disagree	36.65
Somewhat disagree	54.05	Somewhat disagree	35.23
Somewhat agree	12.10	Somewhat agree	10.32
Strongly agree	6.05	Strongly agree	2.14
At times, I think I am no good at all	21.35	I feel that I'm a person of worth, at least on equal plane with others	10.68
Strongly disagree	55.87	Strongly disagree	53.74
Somewhat disagree	16.73	Somewhat disagree	33.45
Somewhat agree	2.85	Somewhat agree	3.91
Strongly agree	18.15	Strongly agree	15.30
I feel that I have a number of good qualities	53.74	I wish I could have more respect for myself	45.20
Strongly disagree	25.27	Strongly disagree	35.59
Somewhat disagree	4.63	Somewhat disagree	18.51
Somewhat agree	12.10	Somewhat agree	40.93
Strongly agree	51.60	Strongly agree	30.60
I am able to do things as well as most other people	31.67	All in all, I am inclined to feel that I am a failure	9.96
Strongly disagree	12.46	Strongly disagree	5.69
Somewhat disagree	38.79	Somewhat disagree	24.20
Somewhat agree	40.21	Somewhat agree	48.75
Strongly agree	8.54	Strongly agree	21.35
I feel I do not have much to be proud of		I take a positive attitude toward myself	
Strongly disagree		Strongly disagree	
Somewhat disagree		Somewhat disagree	
Somewhat agree		Somewhat agree	
Strongly agree		Strongly agree	

with myself"). The following 4-point scale was used: strongly disagree (1), somewhat disagree (2), somewhat agree (3), and strongly agree (4). After reversing the scores of the five negative statements (e.g., "At times, I think I am no good at all" and "I certainly feel useless at times"), the 10 response ratings were summed to obtain the total self-esteem score. Higher score indicated higher self-esteem. Overall, 72.6% of the participants agreed with the statement that "At times, I think I am no good at all." It is also consistent with previous research findings that female college students have higher levels of stress related to academic pressure and being overweight [46]. In contrast, 87.19% agreed with the statement: "I feel that I am a person of worth, at least on an equal plane with others." The detailed answer choices to the self-esteem questions are shown in Table 4.

Of the participants, 48.9% reported that they had used a wearable device. The most commonly owned wearable devices were Apple Watch (53.85%) and Galaxy Watch (24.79%), followed by Xiaomi (7.69%) (see Table 5). Most participants had owned their device for less than six months (26.32%), less than three months (21.05%), or less than one year (17.29%). The biometric information collected by the device included number of steps (75.19%), heart rate (55.64%), and workout (51.88%) data. Participants reported that the reason to constantly use the device was "used as a watch" (48.87%), "to increase physical activity" (40.60%), "to record biometric data" (36.84%), "design is aesthetic" (36.09%), and "to manage diet and body shape (25.56%)." Moreover, 66.15% of wearable device users used health-related mobile apps, such as menstrual period trackers or food intake analysis apps.

Surprisingly, for the wearable device users, the most common biometric information typically recorded separately was menstrual cycle and menstrual cramps (dysmenorrhea) (53.85%). Similarly, for nonusers of the devices, menstrual cycle and menstrual cramps (62.88%) were the most common biometric information that was usually recorded and 62.88% reported that they used mobile apps to track health-related information. Most nonusers stated that they were unable to use the device for financial reasons (77.14%), and 65% of the respondents reported that they would be willing to use a smartwatch in the future.

3.2. Factors affecting self-esteem

The linear regression method was used to assess the factors that affect self-esteem. The Durbin-Watson statistic showed a value of nearly 2.0, indicating that there was no autocorrelation detected in the sample. Linear regression results showed that stress (beta = −0.627, t = −13.453, p < .01), physical activity intensity (beta = 0.193, t = 3.067, p < .05), eating attitude (beta = −0.189, t = −3.155, p < .01), and college life satisfaction (beta = 0.174, t = 2.894, p < .01) significantly affected self-esteem (see Table 6). Stress was found to have a statistically significant negative effect on self-esteem, and when stress increased by 1, self-esteem changed by −0.641. This indicates that stress and self-esteem are related and that stress may lower self-esteem. Physical activity intensity had a statistically significant positive effect on self-esteem. When physical activity intensity increased by 1 unit, self-esteem increased by 0.085. The results indicate that physical activity helps improve self-esteem. College life satisfaction was significantly and positively correlated with self-esteem. For every 1 unit increase in college life satisfaction, self-esteem increased by 0.118. In other words, higher satisfaction with college life leads to higher self-esteem. Eating attitude had a statistically significant negative effect on self-esteem. The higher the EAT score, the more prone the respondent is to anorexia and bulimia. The linear regression results showed that when eating attitude increased by 1 unit, self-esteem changed by −0.137. This indicates that eating disorders are correlated with self-esteem.

Table 5
Responses to the wearable device questionnaire.

Questions	%	Questions	%
Do you have any use experience with wearable devices (e.g., Apple Watch,	48.94	*(User Question) Do you have biometric information that you usually*	25.38
Galaxy Gear, Fitbit, etc.)?	51.06	*record separately? * *	8.46
Yes	5.13	None	53.85
No	53.85	Food intake and calories	23.08
(User Question) What device brand have you been using?	24.79	Menstrual cycle and menstrual cramps	14.62
Fitbit	7.69	Physical activity	21.54
Apple Watch	3.42	Sleep	1.54
Galaxy Watch	5.13	Weight	66.15
Xiaomi	11.28	Others	33.85
Galaxy Gear	11.28	*(User Question) Have you ever used a smartphone health-related mobile*	77.14
Others	21.05	*app?*	6.43
(User Question) How long have you been using the device?	26.32	Yes	3.57
less than 1 week	17.29	No	78.57
less than 1 month	8.27	*(Non-user Question) If you have no experience with the device, why? * *	0.00
less than 3 months	4.51	Because of the cost	3.57
less than 6 months	75.19	I don't like the design	65.15
less than 1 year	55.64	I don't like the functions/features	13.64
less than 2 years	33.83	I don't feel the need to use it	21.21
more than 2 years	37.59	Due to data security issues	25.00
(User Question) What biometric data do you primarily measure with	36.09	Other	15.15
*your device? * *	51.88	*(Non-user Question) If given the opportunity in the future, would you be*	62.88
Steps	6.02	*willing to use a smartwatch?*	24.24
Heart rate	10.53	Yes	16.67
Distance	3.01	No	31.82
Calories	21.05	Don't know	4.55
Sleep	40.60	*(Non-user Question) Do you have biometric information that you*	62.88
Workout	36.09	*usually record separately? * *	37.12
Blood oxygen	48.87	None	
Electrocardiogram (ECG)	36.84	Food intake and calories	
Others	20.30	Menstrual cycle and menstrual cramps	
*(User Question) Why do you constantly use your device? * *	25.56	Physical activity	
N/A (Not using anymore)	15.79	Sleep	
To increase physical activity	1.50	Weight	
Design is aesthetics		Others	
Used as watch		*(Non-user Question) Have you ever used a smartphone health-related*	
To record biometric information		*mobile app?*	
To identify health abnormality		Yes	
To manage diet and body shape		No	
To manage sleep			
Others			

Note. * Multiple selection possible.

Table 6
Association between stress, physical activity, eating attitude, college life satisfaction, wearable device use experience and self-esteem using linear regression analysis.

Variables	Self-esteem						
	B	Std Err	Beta	t	p	DW	R²
Stress	−.641	.048	−.627	−13.453	.000**	1.826	.393
Physical activity intensity	.085	.028	.193	3.067	.002**	2.000	.063
Eating attitude	−.137	.043	−.189	−3.155	.002**	2.051	.036
College life satisfaction	.118	.041	.174	2.894	.004**	2.057	.030
Experience of Wearable Device	.206	.074	.164	2.772	.006**	2.016	.027

Note. *$p < .05$, **$p < .01$.

Table 7
Association between physical activity time, eating attitude and stress using linear regression analysis.

Variables	Stress						
	B	Std Err	Beta	t	p	DW	R²
Physical Activity Time	−.095	.036	−.168	−2.659	.008**	2.001	.037
Eating Attitude	.138	.044	.188	3.136	.002**	2.007	.035

Note. *$p < .05$, **$p < .01$.

Table 8

Association between experience wearable device use, wearable device usage period and physical activity intensity using linear regression analysis.

	Physical Activity Intensity						
Variables	B	Std Err	Beta	t	p	DW	R^2
Experience of Wearable Device (User)	.356	.169	.125	2.113	.036*	1.995	.016
Wearable Device Usage Period	.173	.078	.191	2.223	.028*	1.905	.036

Note. *p < .05, **p < .01.

3.3. Factors affecting stress

To determine the factors that affect stress, a linear regression method was adopted. The Durbin-Watson statistics results showed a value of nearly 2.0, which indicates that no autocorrelation was detected in the sample. Linear regression results showed that physical activity time (beta = −0.168, t = −2.659, p < .01) and eating attitude (beta = 0.118, t = 3.136, p < .01) significantly affected stress (see Table 7). Physical activity time had a statistically significant negative effect on stress. The results indicate that longer physical activity helps lower the stress level. In contrast, eating attitude had a positive effect on stress. The linear regression results showed that when eating attitude increased by 1 unit, stress increased by 0.138. This means that eating disorders are correlated with stress and that eating disorders can exacerbate mental stress. Constant worrying about food and weight can lead to considerable anxiety, lower self-esteem (Table 6), and stress.

3.4. Factors affecting physical activity and wearable device

To explore the relationship between physical activity and wearable devices, linear regression analysis was performed. The Durbin-Watson statistical results indicate a value of nearly 2.0, which means that no autocorrelation was detected in the sample. Linear regression results showed that the experience of wearable devices (beta = 0.125, t = 2.113, p < .05) and wearable device use time period (beta = 0.173, t = 2.223, p < .05) were significantly correlated with physical activity (see Table 8).

Wearable device use had a statistically significant positive effect on physical activity intensity. The intensity of physical activity was higher for users than for nonusers. Thus, the use of wearable devices can help increase physical activity. Furthermore, the wearable device usage period had a statistically significant positive effect on physical activity intensity. Among wearable device users, the results show that the longer the period of the device use, the higher the intensity of physical activity performed by the user. These results suggest that the use of wearable devices and longer device use can help increase physical activity intensity.

Interestingly, the research revealed a relationship between the experience of wearable device use and self-esteem (see Table 6). The statistical results show that the experience of wearable devices (beta = .164, t = 2.772, p < .01) had a statistically significant positive effect on self-esteem. Therefore, those who have experienced using wearable devices have higher self-esteem than those who have not.

4. Discussion

This study examined female college students' health-related quality of life (HRQoL), analyzed the correlations between college life satisfaction, physical activity, stress level, eating attitudes, self-esteem, and use of wearable devices. Using this information, this study examined the relationship between wearable devices and physical activity to identify the requirements for smartphone applications for healthcare.

The female college students in this study reported that the leading factors causing them stress in the past six months were being tired (55.94%), COVID-19 (52.10%), midterm and final exams (49.65%), worrying about grades (47.20%), concerns about finding a full-time job after graduation (39.86%), menstruation (35.31%), and dissatisfaction with their weight (33.92%) (see Table 5). Our study also found significant associations between tiredness, COVID-19, and menstrual cycles and stress among female college students, in addition to academic and exam pressures, financial problems, and perceived body image. This finding aligned with Gao et al.'s results that high anxiety levels among female college students were related to their self-perceived physical image and academic achievement [5]. It also aligned with Anbumalar et al.'s finding that college students experience stress because of exam pressures and financial problems [47].

This study discovered that when a female college students' stress increased by 1 point, their self-esteem decreased by 0.641. This is consistent with Hubbs et al.'s findings that the higher the stress, the lower the self-esteem [48]. According to this study analysis, self-esteem increased with the intensity of physical activity. When the intensity of physical activity increased by 1 unit, self-esteem increased by 0.085. Thus, the female college students who exercised with stronger intensity reported higher self-esteem. This is consistent with previous studies showing a significant correlation between physical activity and self-esteem [49–51]. Furthermore, Gilani and Dashipour found that 84 male medical students who participated in an eight-week aerobic exercise program reported increased self-esteem after the exercise program [52]. Our research is meaningful in that it focuses on factors affecting the self-esteem of female college students, and it shows results that are similar to previous studies targeting male participants.

For the relationship between college life satisfaction and self-esteem, this paper explored that when college life satisfaction increased by 1 unit, self-esteem increased by 0.118; the higher the satisfaction with college life, the higher the self-esteem. This is consistent with Zhang et al.'s results from a survey of 439 undergraduate students in China on college life satisfaction; they found a positive correlation among female college students between college life satisfaction, self-esteem, liberal attitudes, and social support

[53].

This study also discovered that when female college students' physical activity time increased by 1 unit, their stress decreased by 0.095. This is consistent with the findings of previous studies [15,17] indicating that physical activity could relieve stress. Meyer and Larson found a statistically significant negative relationship between the frequency of physical activity and academic performance [54]. Likewise, Ge et al. reported that female college students who engaged in only light or moderate were more prone to stress than those who engaged in high-intensity physical activities [55]. This is consistent with the research results.

As our study's female college students' Eating Attitude Test (EAT) scores increased, their likelihood of having anorexia or bulimia increased. When the EAT score increased by 1 unit, stress increased by 0.138. This supports Torres and Nowson's finding that stress can affect eating patterns [56]. This study findings on the relationship between eating attitude and stress were consistent with Penaforte et al.'s results from a survey to determine the correlation between college students' stress levels and eating attitudes [57]. They found that students with higher stress levels had higher scores for emotional eating and uncontrolled eating.

According to our survey results, 48.94% of the respondents used wearable devices, and 65.14% of those who did not use them intended to in the future. Furthermore, 62.88% of the nonusers had experienced using health-related mobile apps on smartphones to record their biometrics. People who had used wearable devices reported higher physical activity intensities than those with no experience using them. This finding suggests that using wearable devices could increase physical activity. The users with wearable device experience reported higher physical activity intensity levels when they used the devices for a longer period, which aligned with Washington et al. and Coughlin and Stewart suggesting that wearable devices help promote physical activity [58,59]. Although this study found some evidence that people who used wearable devices had higher self-esteem than those who did not, it was difficult to compare them because of the lack of previous research on the correlation between wearable device experience and self-esteem. Future studies should explore this relationship further.

When female college students were asked which health-related applications they were most interested in, the most frequently mentioned were those that tracked exercise, food (nutrition and calories), and menstrual cycles. Some of the most-requested functions were these: (1) a function that calculated calories automatically from a picture of food; (2) a function that calculated their cumulative ingested calories and used that input to calculate how much they would need to exercise to maintain (or increase or decrease) their weight; (3) a function that calculated their metabolic rate based on their height and weight; (4) a function that predicted their menstrual cycle and suggested exercises suited to the heaviness of their flow.

The study findings revealed significant interest among female college students in health-related apps for tracking menstrual cycles and food intake, regardless of whether they involved wearable devices. The study found that 53.85% of the wearable device users and 62.88% of the nonusers—more than half the women we surveyed—wanted biometric information on menstrual cycles and menstrual cramps, regardless of whether they used a wearable device or not. Many commented that wearable device app developers were not doing enough to meet the needs of female college students.

One of the study's limitations was that only female college students participated in the study. Although this study targeted female college students, in order to find how the factors of male and female are different, especially in the implication of the design, it is better to conduct a comparative analysis or multi-group analysis targeting male and female students in a future study.

5. Conclusion

This study collected and analyzed health-related data from female college students, identifying the correlations between college life satisfaction, physical activity, stress level, eating attitude, and self-esteem. In addition, as wearable devices promote physical activity, this study investigated the relationship between their user experience and physical activity among female college students and looked into their need for smartphones or wearable-device apps for healthcare.

The female college students who participated in our study reported that the leading factors causing them stress in the past six months were being tired, COVID-19, midterm and final exams, grades, finding a full-time job after graduation, menstruation, and their weight. The results discovered that when their stress increased, their self-esteem decreased. In addition, when their physical activity increased, their self-esteem increased, and their stress decreased. Furthermore, when their satisfaction with college life increased, their self-esteem increased.

The Eating Attitude Test (EAT) results suggested a correlation between high stress and disposition to anorexia/bulimia nervosa. People who had used wearable devices showed higher physical activity intensity than those who had not. More than half the female college students' respondents usually recorded biometric information on their menstrual cycles and menstrual cramps, regardless of whether they used wearable devices or not. Health-related apps currently in use are separately measured and provided with diet, menstrual cycle, and exercise volume, which are inconvenient to use, so there was a demand that students needed an app in an integrated form. Therefore, it was confirmed that a tailored app was needed for integrating and managing these health-related data interworking with a wearable device is needed, and the programmer(s) should positively reflect female college students' needs while developing apps in future. In addition, as statistics show they have a high willingness to use wearable devices, it is necessary to apply new information technology to create an environment that meets the needs of female college students' health management.

Funding statement

Summary Table

What are already known?

- Female college students experience many new challenges when they enter college or university in the early stage of adulthood and they had experienced anxiety or depression above the average level
- Health behaviors and health status can directly impact female college students' sleep quality, stress levels, and life satisfaction
- Digital health technologies such as wearable devices encourage health-promoting behaviors by increasing physical activity and causing various changes in people's lifestyles
- Few studies conducted on female college students' mental health and physical activities to identify factors that affect their intention to use wearable health-monitoring devices.

What this study adds?

- Derived correlations between female students' college life satisfaction, physical activity, stress level, eating attitude, and self-esteem.
- Discovering the relationship between female college students' use of wearable devices and physical activity and examined the requirements for smartphone applications for healthcare.
- Measured female college students' mental health and physical activities to identify factors that affect their intention to use wearable health-monitoring devices

Ethical approval

The ethics committee of Sookmyung Women's University approved this study.

Author contribution statement

Grace Donghee Shin: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Wookyoung Jeong: Contributed reagents, materials, analysis tools or data.

Hye-Eun Lee: Conceived and designed the experiments; Contributed reagents, materials, analysis tools or data.

Data availability statement

Data will be made available on request.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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