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Prediction model of intention to use digital fitness services for health promotion during the COVID-19 pandemic: a gender-based multi-group analysis

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Abstract

As the number of people infected with COVID-19 in Korea is increasing, several measures have been implemented to gradually restrict outdoor activities and indoor gatherings while promoting a non-face-to-face social culture. In this study, we performed a gender-based multi-group analysis using a technology acceptance model (TAM) as an external variable for COVID-19 risk perception to verify the model's predictive ability to increase participation behavior toward digital fitness services. We analyzed the data of 433 Koreans using an online survey consisting of 23 items. A structural equation model was used to verify the perceived ease of use (PEOU), perceived usefulness (PU), intention to use and exercise participation behavior of the TAM with COVID-19 risk perception as an external variable. First, our results showed that COVID-19 risk perception had a statistically higher significant and positive effect on PEOU ($\beta = 0.170$, $t = 3.296$, $p < 0.001$) than on PU ($\beta = 0.130$, $t = 2.848$, $p = 0.004$) of digital fitness services. Second, the PEOU of the digital fitness service was found to have a statistically higher significant positive effect on PU ($\beta = 0.512$, $t = 9.728$, $p < 0.001$) than on intention to use ($\beta = 0.130$, $t = -2.774$, $p = 0.006$). Third, the PU of digital fitness services was found to have a statistically significant positive effect on the intention to use ($\beta = 0.684$, $t = 12.909$, $p < 0.001$). Fourth, the intention to use the digital fitness service was found to have a statistically significant positive effect on exercise participation behavior ($\beta = 0.796$, $t = 16.248$, $p < 0.001$). Lastly, we observed a significant difference between men and women in COVID-19 risk perception and PEOU among the six paths established. Digital environments that encourage participation in exercises could promote health during a pandemic. This study highlighted the need to consider digital environments that encourage exercise participation in creating physical exercise contents as there was no significant difference in the intention to use digital fitness services between men and women.

Keywords

Technology acceptance model; Digital fitness; Exercise participation behavior; Gender differences

1. Introduction

COVID-19 was declared a pandemic after it first emerged in Wuhan, China, in December 2019 [1]. According to the World Health Organization, at present (as of 15 August 2022), 594,267,413 people in 221 countries have been infected with COVID-19, and 6,456,627 people have died because of it [2]. Vaccines and therapeutics are being administered to those infected with COVID-19; however, studies have shown that COVID-19 cases will continue to increase because of the emergence of various mutated strains [3].

In Korea, the increase in the number of confirmed COVID-19 cases has limited outdoor activities and indoor gatherings and led to a non-face-to-face social culture [4]. Additionally,

depending on the number of confirmed cases, outdoor activities and indoor gatherings are limited by stage, and a non-face-to-face social culture is gradually being induced using online technology [5]. Moreover, despite the social distancing policies implemented, the number of infected people is rapidly increasing because of a new mutant virus in Korea [6]. As COVID-19 is transmitted by respiratory droplets from an infected person, it is important to minimize face-to-face contact to prevent infection [7]. Therefore, non-face-to-face exercise and sports participation *via* home training [8], social media [9] and virtual reality [10] are gaining increasing popularity as new platforms for exercise engagement [11]. During the COVID-19 pandemic, home training-related contents provided through platforms such as YouTube have significantly increased [12].

The limited outdoor activities and social interactions because of the COVID-19 pandemic can lead to mental health issues, such as stress, depression and anxiety [13–15]. Thus, to avoid these issues, people are gradually switching to online communication technologies and digital devices to explore non-face-to-face exercise services [16]. It was reported that there is currently an increase in home training through real-time video services, such as YouTube, whereby YouTubers provide a variety of exercise-related contents that allows users to watch and participate in different exercises [17]. As the Korean government's social distancing policy has led to the closure or reduced usage hours of indoor sports facilities, online technology-oriented non-face-to-face exercise services are becoming more common [18]. However, this type of exercise is a new form of the existing offline-oriented exercise, and some limitations are expected considering the essential characteristics of exercises, including the associated environment. Compared with the offline environment, it is challenging to perform large-muscle exercises *via* online-oriented settings because such online platforms use relatively narrow space, which might not be suitable for such exercises. In addition, it takes a long time to learn the correct exercise posture alone, and injuries might occur because of incorrect postures [19]. Other challenges include difficulty in using different equipment and continuously motivating exercise behaviors [20].

Therefore, it is necessary to verify whether the use of a digital fitness service could overcome the limitations of existing online exercise and whether it could effectively replace the role of traditional offline exercise during the COVID-19 pandemic. To verify this necessity, the intention to use non-face-to-face exercise services was assessed using the Davis' technology acceptance model (TAM) [21], which considers COVID-19 risk perception as an exogenous variable. TAM provides a theoretical foundation for predicting users' intentions to accept technology in a new technology-based service environment. Specifically, it predicts the actual behavior of a user by identifying the relationship between the user's intention and behavior toward a new technology based on external variables such as perceived ease of use (PEOU) and perceived usefulness (PU) [22]. As TAM is based on a relatively simple and clear rationale, previous studies have used it to identify user behaviors toward new technologies [23, 24].

Prior studies found significant differences between men and women in motivation and exercise participation [25–27], as men and women have different physiological body compositions [28], possibly related to the close relationship between body composition and exercise performance [29]. In addition, there is a considerable difference between men and women in terms of muscle and fat composition [30]. Gender differences have also been identified in TAM, and gender has been studied in various fields as a major variable to explain human TAM [31]. Furthermore, differences in technology acceptance between men and women have also been verified in previous studies [32, 33], which showed that gender differences might influence exercise participation.

In this study, we attempted to validate a predictive model for the intention to use digital fitness services by applying TAM as an exogenous variable to the perception of the risk of COVID-19 by gender. Additionally, an effective exercise performance method related to digital fitness services could be provided by identifying how each method is influenced by gender. These findings might provide academic information for the growth of the digital fitness service and suggest a new exercise trend in the post-COVID-19 era.

2. Literature review

2.1 Relationship between COVID-19 risk perception, perceived ease of use, perceived usefulness, intention to use, and behavior toward digital fitness services

Studies have been conducted on PEOU, PU, intention to use and behavior toward digital fitness services during COVID-19. Gomez-Ruize *et al.* [34] found that the attractiveness, PEOU and PU of fitness applications (apps) for fitness center users during the COVID-19 pandemic positively affected their intention to exercise through an app. Ardion and Sabrina [35] also reported that the PEOU and PU of fitness apps positively affected users' intentions in using them. In addition, a previous study revealed that new exercise services based on platform technology, such as online-to-offline (O2O) services, positively affected exercise participation [36]. Based on these findings, we hypothesize that there might be a relationship between COVID-19 risk perception and TAM in predicting the intention to use based on the PEOU and PU of users in the field of information and communication technology (ICT).

ICT platforms are useful online tools during the COVID-19 pandemic [37] as they can promote overall physical activity [38]. TAM is a powerful model that can predict user behavior by identifying the relationship between PEOU, PU, intention to use and behavior in the ICT field [21, 22]. PEOU refers to users' perception that new technologies and systems can be used with little effort [39]. PU is defined as the recognition that using a particular system would help improve individual performance [39]. Venkatesh and Davis [40] explained that PEOU and PU directly affected users' behavioral intentions, such as acceptance intention, because they are both determined by cognitive judgments, and suggested that the explanatory power of TAM could be enhanced by adding external variables that explain individual characteristics or social influence [40].

Based on these theoretical relationships, the intention to use digital fitness services during the COVID-19 pandemic can be verified if COVID-19 risk perception is input as an external variable. Therefore, the following hypotheses were established in this study:

Hypothesis 1 (H1): COVID-19 risk perception positively affects the PEOU of digital fitness services.

Hypothesis 2 (H2): COVID-19 risk perception positively affects the PU of digital fitness services.

Hypothesis 3 (H3): The PEOU of digital fitness services positively affects their PU.

Hypothesis 4 (H4): The PEOU of digital fitness services positively affects the intention to use.

Hypothesis 5 (H5): The PU of digital fitness services positively affects the intention to use.

Hypothesis 6 (H6): The intention to use digital fitness services positively affects exercise participation behavior.
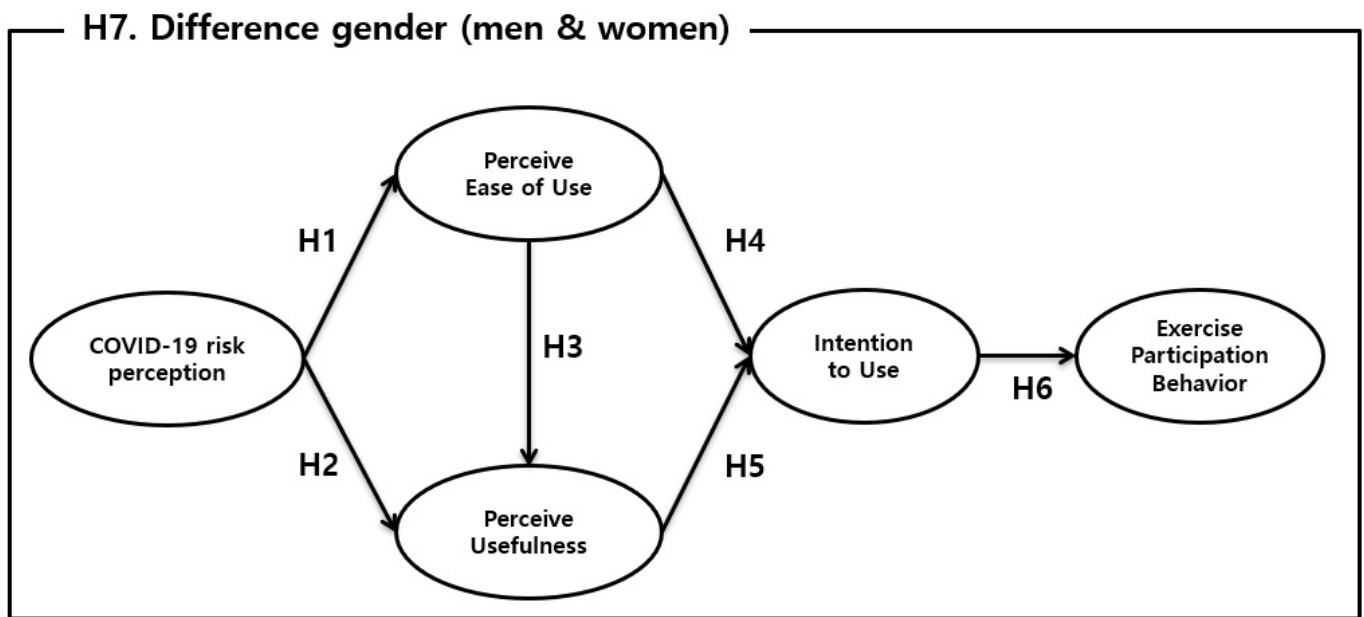
FIGURE 1. Research model. H1: Hypothesis 1; H2: Hypothesis 2; H3: Hypothesis 3; H4: Hypothesis 4; H5: Hypothesis 5; H6: Hypothesis 6.

2.2 Multi-group analysis of gender with COVID-19 risk perception, perceived ease of use, perceived usefulness, intention to use, and behavior toward digital fitness services

Several studies have reported a significant difference in the motivation and participation in exercises between men and women [41, 42]. Thus, to verify the intention of using digital fitness services through TAM, it was considered that the magnitude of the influence of each path might vary according to gender. In addition, we observed a significant difference between male and female body perception levels [43], which was supported by a previous research in which men and women were reported to also differ significantly in their self-directed exercise abilities [44].

Based on these theoretical relationships, a significant difference in the intention to use digital fitness services was expected according to the gender of exercise participants. Therefore, the following hypothesis was also established:

Hypothesis 7 (H7). The relationship between COVID-19 risk perception, perceived ease of use, perceived usefulness, intention to use, and exercise participation behavior of digital fitness services differed according to gender.

Fig. 1 shows the research model used in this study, based on the established research hypothesis.

3. Materials and Methods

3.1 Data collection

This study included a large number of unspecified adult men and women residing in Korea. Conducting a face-to-face survey was difficult because of the spread of COVID-19 in Korea. Data were collected using non-face-to-face online questionnaires (NAVER Forms). Research participants were recruited through NAVER's (NAVER Corp., Seongnam, Korea) online community, the most commonly used online platform in Korea [45].

The survey was conducted from September 2021 to December 2021 using convenience sampling. The number of COVID-19 cases in South Korea in 2021 decreased to 59,899 in September and 53,450 in October, then sharply increased to 82,565 in November and 183,680 in December [46]. In total, 449 questionnaires were collected, of which 443 (99.3%) were used for analysis, and six with the same number or missing values were excluded. The participants were men (n = 251) and women (n = 192) aged 20–29 (n = 228), 30–39 (n = 139) or over 40 (n = 76) years old. The responses were low among those in their 50s (n = 4); thus, the survey finally specified "those in their 40s or older". The weekly exercise frequency was less than once a week (n = 161), 1–2 times a week (n = 161), 3–4 times a week (n = 77), or 5 or more times a week (n = 44). The frequency of weekly exercise participation (such as walking, mountain climbing, and bodybuilding) was set based on the items of the "Sports White Paper", published annually by the Korean Ministry of Culture, Sports and Tourism [47]. According to the "2019 Sports White Paper" survey conducted in 2021 [47], the frequency of exercise was measured on a weekly basis to assess the participation of more than 30 minutes during a single exercise. The frequency of exercise used in this study was also measured based on the "2019 Sports White Paper" [47], and related contents were added under the questionnaire to guide respondents to respond correctly. Table 1 presents the demographic characteristics of the participants.

3.2 Survey instrument

A questionnaire was used for this study, and all items except for the demographic characteristics (gender, age and exercise frequency) of the study consisted of a 5-point Likert scale ranging from "not at all" to "strongly agree". The questionnaire

T A B L E 1. The demographic characteristics of the study population.

Collection category	n	%
Gender		
Men	251	56.7
Women	192	43.3
Age		
20s	228	51.5
30s	139	31.4
Over 40s	76	17.1
Frequency of weekly exercise		
Under once a week	161	36.3
Once or twice a week	161	36.3
Three or four times a week	77	17.4
Five or more times a week	44	10.0
Total	443	100.0

contained 23 items, including three related to demographic characteristics. The COVID-19 risk perception comprised five questions based on the World Health Organization Quality of Life (WHOQoL) brief version provided by [48] and was modified for this present study [49]. PEOU and PU consisted of eight questions, four each, which were originally developed by [24, 50, 51] and modified for this study. Intention to use and behavior consisted of a total of six items, with three items each, by modifying and supplementing the items used in studies [51, 52]. In the online questionnaire, explanations were presented with pictures to help the participants understand the digital fitness service. In addition, as this study used questionnaire items from previous studies, the questionnaires were submitted to three expert panels composed of sports and exercise-participating behavioral professors for content validity. The evaluation of the relevance, comprehensiveness and comprehensibility of the questionnaire's construct was verified through an expert panel. A pilot test (50 copies) of the questionnaire based on its content validity was performed to determine the reliability of the construct, which was found to be 0.924 (COVID-19 risk perception), 0.906 (PEOU), 0.926 (PU), 0.952 (intention to use), and 0.917 (exercise participation behavior). Then, the follow-up procedure was performed.

3.3 Statistical analysis

Frequency analysis, descriptive statistical analysis, confirmatory factor analysis (CFA), reliability analysis, Pearson's correlation analysis, structural equation model (SEM) verification and multi-group analysis were performed on the collected data using the SPSS v23.0 and AMOS v23.0 (IBM Corp., Armonk, NY, USA) software. We used five model fit indices to assess the goodness of fit (root mean square error of approximation (RMSEA), chi-square, incremental fit index (IFI), Tucker-

Lewis index (TLI), and comparative fit index (CFI)). Statistical significance was set at $p = 0.05$.

4. Results

4.1 Validity and reliability of the survey instrument

CFA was performed to ensure the validity of the questionnaire. As shown in Table 2, the fitness index of the measurement model satisfied all the fitness criteria suggested by Kline *et al.* [53]. The construct reliability (CR) of the five observation variables was 0.860–0.944, and the average variance extracted (AVE) was 0.611–0.826, ensuring convergent validity [54]. As the AVE values of all factors used in this study (minimum 0.611) were larger than the square value of the correlation coefficient (maximum 0.594), discriminant validity between constructs was confirmed [54]. In addition, the reliability values of all constructs exceeded 0.70, confirming that all reliability criteria were satisfied [55]. Table 2 presents the results of the validity and reliability analyses of the components.

4.2 Normality of data and Pearson's correlation analysis

The normality of the data was verified based on the results of the descriptive statistical analysis of the five variables used in this study. As the SEM assumes multivariate normality, the analysis was performed assuming that the observed variables followed a normal distribution. Therefore, as the maximum likelihood method was used for parameter estimation, we tested the normality of the data by conducting a normality analysis. According to the proposal of West *et al.* [56], all variables' values were within the range of skewness ± 2 and kurtosis ± 7, ensuring data normality. In addition, the Pearson's correlation coefficient between all variables was less than 0.85, indicating no multicollinearity issue [53]. Table 3 shows the results of data normality verification and Pearson's correlation analysis.

4.3 Structural Equation Modeling (SEM)

4.3.1 Relationship between COVID-19 risk perception, perceived ease of use, perceived usefulness, intention to use, and behavior toward digital fitness services

Table 4 shows the results of the validation of the suitability of the SEM set to test Hypotheses 1 to 6 of this study. All fitness indices, except for the chi-square, which is sensitive to sample size, met the criteria suggested by Kline [53].

First, COVID-19 risk perception showed a statistically significant positive effect on the PEOU ($\beta = 0.170$, $t = 3.296$, $p < 0.001$) and PU ($\beta = 0.130$, $t = 2.848$, $p = 0.004$) of digital fitness services, supporting hypotheses 1 and 2. Second, the PEOU of digital fitness services was found to have a statistically significant positive effect on PU ($\beta = 0.512$, $t = 9.728$, $p < 0.001$) and intention to use ($\beta = 0.130$, $t = -2.774$, $p = 0.006$) digital fitness services, suggesting that hypotheses 3 and 4 were supported. Third, the PU of digital fitness services was found to positively affect the intention to use ($\beta = 0.684$, $t = 12.909$, p

TABLE 2. Results of the validity and reliability analyses.

Measurement Items	Loading (χ)	S.E.	CR	AVE	α
COVID-19 risk perception 1	0.873	-			
COVID-19 risk perception 2	0.895	0.029			
COVID-19 risk perception 3	0.871	0.038	0.944	0.770	0.947
COVID-19 risk perception 4	0.876	0.038			
COVID-19 risk perception 5	0.872	0.040			
Perceive ease of use 6	0.786	-			
Perceive ease of use 7	0.876	0.055	0.860	0.611	0.866
Perceive ease of use 8	0.831	0.054			
Perceive ease of use 9	0.606	0.060			
Perceive usefulness 10	0.770	-			
Perceive usefulness 11	0.763	0.057	0.879	0.646	0.879
Perceive usefulness 12	0.806	0.060			
Perceive usefulness 13	0.872	0.062			
Intention to use 14	0.847	-			
Intention to use 15	0.902	0.044	0.923	0.801	0.923
Intention to use 16	0.934	0.043			
Exercise participation behavior 17	0.786	-			
Exercise participation behavior 18	0.931	0.048	0.934	0.826	0.920
Exercise participation behavior 19	0.985	0.051			

Note. S.E.: standard error; CR: construct reliability; AVE: average variance extracted; α: Cronbach's alpha; $\chi^2 = 448.998$ (p < 0.001), df = 138, incremental fit index = 0.958, Tucker-Lewis index = 0.948, comparative fit index = 0.958, root mean square error of approximation = 0.071.
Tested by confirmatory factor analysis and reliability analysis.

TABLE 3. Results of Pearson's correlation and normality analyses.

Items	COVID-19 risk perception	PEOU	PU	Intention to use	Exercise participation behavior
1	AVE = 0.703				
2	0.491 (0.241)**	AVE = 0.712			
3	0.687 (0.471)**	0.455 (0.207)**	AVE = 0.716		
4	0.621 (0.385)**	0.771 (0.594)**	0.381 (0.145)**	AVE = 0.790	
5	0.196 (0.038)**	0.194 (0.037)**	0.152 (0.023)**	0.204 (0.041)**	AVE = 0.755
Mean	3.22	4.09	3.57	3.27	2.82
Standard deviation	1.06	0.67	0.73	0.96	1.12
Skewness	−0.587	−1.079	−0.475	−0.215	0.105
Kurtosis	−0.445	3.060	0.484	−0.206	−0.807

**p < 0.01.
Note. AVE: average variance extracted; PEOU: perceived ease of use; PU: perceived usefulness.
Tested by descriptive statistical analysis and Pearson's correlation analysis.

TABLE 4. Structural equation modeling.

	Path	β	S.E.	t	p	Hypothesis testing
H1	COVID-19 risk perception → PEOU	0.170	0.031	3.296	0.000	Adopted
H2	COVID-19 risk perception → PU	0.130	0.033	2.848	0.004	Adopted
H3	PEOU → PU	0.512	0.063	9.728	0.000	Adopted
H4	PEOU → Intention to use	0.130	0.062	2.774	0.006	Adopted
H5	PU → Intention to use	0.684	0.059	12.909	0.000	Adopted
H6	Intention to use → Exercise participation behavior	0.796	0.054	16.248	0.000	Adopted

Note. H: hypothesis; PEOU: perceived ease of use; PU: perceived usefulness; χ^2 = 570.551 (p < 0.001), df = 145, incremental fit index = 0.943, Tucker-Lewis index = 0.932, comparative fit index = 0.942, root mean square error of approximation = 0.081.

< 0.001), indicating that hypothesis 5 was supported. Fourth, the intention to use digital fitness services positively affected exercise participation behavior (β = 0.796, t = 16.248, p < 0.001), which supported hypothesis 6.

4.3.2 Multi-group analysis of gender with COVID-19 risk perception, perceived ease of use, perceived usefulness, intention to use, and behavior toward digital fitness services

A multi-group analysis comparing the path coefficients between groups was conducted to assess the differences in structural relationship between COVID-19 risk perception, PEOU, PU, intention to use and exercise participation behavior for digital fitness services according to gender. In addition, metric invariance and cross-group equality constraints were implemented to compare the path coefficients between the groups.

The metric invariance constraints were used to verify whether the response results between each group within the established research model were the same [57]. The cross-group equality constraint tests were performed to determine the difference between groups in each path after applying a constraint to each regression coefficient, according to the research model [58]. Before performing the comparison between groups, the fit of the model to which the metric invariance constraints were applied and the parameters for each workplace were estimated (Table 5). The model's goodness of fit was χ^2 = 906.493, df = 304, p < 0.001, IFI = 0.919, TLI = 0.908, CFI = 0.919 and RMSEA = 0.067, indicating that the fit criteria were met [53]. In addition, to examine the difference in path coefficients between the two groups, cross-group equality was applied between the groups in the metric invariance model, and the fit was compared. As shown in Table 5, the model's goodness of fit with the cross-group equality constraints was χ^2 = 914.794, df = 310, p < 0.001, IFI = 0.919, TLI = 0.910, CFI = 0.918, and RMSEA = 0.067. The cross-group equality constraints model was like the metric invariance model. Therefore, the cross-group equality constraints were established.

Next, we performed a comparative analysis of the path coefficients for each gender. Specifically, a comparative analysis was performed to confirm whether there was a significant difference between the path coefficients of the model to which the same constraint was applied to each of the six path coefficients in the research model and those of the underlying model. Table 6 shows the results of comparing the path coefficients of the two models. Altogether, our results revealed a significant difference between men and women in the paths of COVID-19 risk perception and PEOU among the six paths established. Therefore, hypothesis 7 was partially supported.

5. Discussion

5.1 Relationship between COVID-19 risk perception, perceived ease of use, perceived usefulness, intention to use, and behavior for digital fitness services

By testing the intention to use and exercise participation behavior of digital fitness services using TAM, we found that our research hypotheses 1 to 6 supported the positive effects in all established routes. These results corresponded with those of previous studies [34, 35], suggesting that the use of digital fitness services can be expanded. These findings could result from preventive policies, such as the closure of indoor sports facilities. In Korea, daily COVID-19-related information are delivered through media, and the opening of indoor sports facilities has been relaxed or strengthened in stages, depending on the number of infected people. Therefore, indoor exercise participants are required to check the latest status of the coronavirus every day. Consequently, our results showed that COVID-19 risk perception positively affected the perceived ease and usefulness of digital fitness services. In Korea, a social atmosphere is being formed wherein the utility of digital fitness services is gradually expanding, such as through the rapid establishment of an over-the-top (OTT) service environment *via* advanced ICT technology. These findings imply that the rapid digitalization of our society because of COVID-19 is establishing new trends in exercise participation.

More specifically, the results of this present study indicated that a higher level of COVID-19 risk perception represents a more positive influence on PEOU and PU of digital fitness services, providing a safer environment. In addition, a previous study revealed that the PEOU and PU of digital fitness services positively affected the intention to use. Despite their many limitations (*i.e.*, progress in a narrow space and concerns about injury due to incorrect posture), the use of digital fitness services and exercise participation behavior is affected by COVID-19.

According to a report on the UN webpage (15 May 2020), in the early days of the COVID-19 outbreak, digital fitness

T A B L E 5. Comparison of the fit between the cross-group constraints model and the base model between groups.

Model	χ^2	df	p	IFI	TLI	CFI	RMSEA
Metric invariance constraints	906.493	304	0.000	0.919	0.908	0.919	0.067
Cross-group equality constraints	914.794	310	0.000	0.919	0.910	0.918	0.067

Note. χ^2: chi square; df: degree of freedom; IFI: incremental fit index; TLI: Tucker-Lewis index; CFI: comparative fit index; RMSEA: root mean square error of approximation = 0.071.

T A B L E 6. Comparison of differences between models and parameter estimates of gender with measurement equivalence constraint applied.

	Path	Men		Women		Δdf	Δχ^2	p	ΔTLI
		β (B)	t	β (B)	t				
H1	COVID-19 risk perception → PEOU	0.226	3.367***	0.066	0.822	1	3.887	0.045	0.000
H2	COVID-19 risk perception → PU	0.163	2.671**	0.104	1.461	1	0.747	0.388	0.000
H3	PEOU → PU	0.489	7.333***	0.487	6.063***	1	0.138	0.711	0.000
H4	PEOU → Intention to use	0.136	2.168*	0.088	1.272	1	0.187	0.666	0.000
H5	PU → Intention to use	0.632	9.373***	0.775	10.388***	1	1.887	0.170	0.000
H6	Intention to use → Exercise participation behavior	0.780	13.890***	0.789	12.179***	1	1.331	0.249	0.000
	All constrained					6	8.301	0.217	−0.001

***p < 0.001, **p < 0.01, *p < 0.05.
Note. df: degree of freedom; TLI: Tucker-Lewis index; PEOU: perceived ease of use; PU: perceived usefulness.

services were expected to expand because of COVID-19 [59]. In addition, Back *et al.* [18] stated that sports activities needed to be improved due to COVID-19 and that the intention to participate in new forms of exercise, such as watching home training through YouTube and video personal training, is projected to increase. Sui *et al.* [17] also predicted that interest in non-face-to-face exercise services would continue even after COVID-19 and argued that attention should now be paid to increasing the usefulness of non-face-to-face exercise services. Based on the results of this and previous studies, it is expected that a higher perceived risk of the COVID-19 pandemic refers to greater dependence on digital fitness services. Therefore, it could be deduced that the PEOU and PU of digital fitness services significantly affected exercise participation behaviors.

5.2 Multi-group analysis of gender with COVID-19 risk perception, perceived ease of use, perceived usefulness, intention to use, and behavior toward digital fitness services

Gender differences were observed in COVID-19 risk perception with PEOU, PU, intention to use and exercise participation behavior for digital fitness services. Specifically, we observed a statistically significant difference in COVID-19 risk perception in the path of PEOU. It can be considered that the results of this study were derived from Korea's policy to suppress participation in sports during the COVID-19 pandemic. The Korean government has controlled the use of indoor and public sports facilities in stages according to the number of COVID-19-infected people. These environments provide an opportunity to expand the use of digital fitness services through ICT developed in Korea. Therefore, the PEOU of digital fitness services increases as COVID-19 risk perception increases. However, in this study, our research results showed that, unlike men, there was no significant relationship between digital fitness services and PEOU in women, which might be because there are more women than men in small-scale sports such as walking exercises, yoga and Pilates, which are often performed outdoors. According to the 2021 Korea National Physical Education Survey [60], we found no significant difference between males and females based on their walking exercise (male: 29.7%, female: 54.4%) and yoga and Pilates (male: 0.6%, female: 14.5%). In other words, no significant relationship was observed between COVID-19 risk perception and the PEOU of digital fitness services because the exercises in which women participated had relatively fewer COVID-19 risk factors than those in which men participate. However, caution should be exercised in generalizing the results of this study as there was a lack of direct preceding studies to support them. Therefore, there is room for reexamining gender differences through follow-up studies.

In this study, we found no difference between the pathways of gender in all TAM pathways, except for hypothesis 1. Several studies have suggested that men and women have

different purposes, methods, forms, and physiological characteristics of exercise participation [28, 61]. In addition, it can be judged that the restriction in exercise participation due to COVID-19 affects the intention to use digital fitness services without any gender-based difference. In other words, these findings suggest that digital fitness services can be easily used by anyone [17] and that the non-face-to-face environment shows no gender differences in the participants' intentions to participate in an exercise.

6. Conclusions

The findings of this study provide valuable information on the need to consider environmental variables when predicting digital fitness use intentions and exercise participation behaviors during a pandemic. Before the COVID-19 pandemic, digital fitness services were largely ignored compared with face-to-face exercise services. Given the current environment, exercise management facilities, such as fitness and public health centers, should increase people's exercise participation by introducing digital fitness services that could effectively replace traditional face-to-face exercise programs. This study also highlighted the need to consider digital environments that encourage exercise participation in creating physical exercise content, as there was no significant difference in the intention to use digital fitness services between men and women. Specifically, digital fitness services should be first provided to men with high PEOU. Our results also suggest that a digital environment encouraging participation in exercise programs can promote health during a pandemic.

7. Limitations

Despite these promising findings, this study had several limitations. First, all data were self-reported, which might have led to respondent, recall, and/or interviewer biases. Second, as the number of people infected with COVID-19 in Korea varies every day, weeks or even months, the level of the perceived risk of COVID-19 might differ. Third, as the survey was conducted using an online community, the participants were mainly in their 20s and 30s, resulting in a limited number of participants in their 40s or older. Therefore, it was difficult to confirm age-related differences in the results of this study. Fourth, it was difficult to control external psychological, social and environmental factors that might occur when identifying the intention to use digital fitness services and exercise participation behavior when using TAM to assess COVID-19 risk perception as a preceding variable. Therefore, caution should be maintained when interpreting the results of this study. Fifth, based on the limitations mentioned above, the generalizability of this study's results should be carefully balanced, especially in other populations.

AUTHOR CONTRIBUTIONS

DKK and SUP—designed the study and the methodology; provided the software; contributed to the formal analysis; contributed to the resource and data curation; contributed to data curation; drafted the manuscript; revised the manuscript; contributed to data visualization; supervised the study; were responsible for project administration. All authors contributed to the editorial changes in the manuscript. All authors have read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study protocol was approved by the Ethics Committee of the Kyung Hee University, Global Campus, Yongin, Republic of Korea (No. KHGIRB-21-421) and conformed to the standards set by the latest revision of the Declaration of Helsinki. Written informed consent was obtained from all study participants.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest. Sung-Un Park is serving as one of the Editorial Board members and Guest Editor of this journal. We declare that Sung-Un Park had no involvement in the peer review of this article and has no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to BG.

REFERENCES

[1] Yonsei University. Facing anxiety and depression amid COVID-19: the "corona blue" message. 2020. Available at: https://www.yonsei.ac.kr/en_sc/yonsei_news.jsp?article_no=189487&mode=view (Accessed: 13 October 2020).

[2] World Health Organization. WHO coronavirus (COVID-19) dashboard. 2022. Available at: https://covid19.who.int/table (Accessed: 15 August 2022).

[3] World Health Organization. A guide to WHO'S guidance. 2020. Available at: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance (Accessed: 17 July 2020).

[4] Korea Ministry of the Interior and Safety. Guidelines for distance in life. 2020. Available at: https://www.mois.go.kr/frt/bbs/type001/commonSelectBoardArticle.do?bbsId=BBSMSTR_000000000012&nttId=78178 (Accessed: 25 June 2020).

[5] Korea Ministry of Health and Welfare. COVID-19 promotes strengthening social distancing. 2021. Available at: http://www.mohw.go.kr/react/al/sal0301vw.jsp?PAR_MENU_ID=04&MENU_ID=0403&CONT_SEQ=368947 (Accessed: 17 December 2021).

[6] Korea Ministry of Health and Welfare. About COVID-19. 2022. Available at: http://ncov.mohw.go.kr/baroView.do?brdId=4&brdGubun=41 (Accessed: 03 March 2021).

[7] Bender L. Key messages and actions for COVID-19 prevention and control in schools. 2020.

[8] Kaushal S, Rajput AS, Bhattacharya S, Vidyasagar M, Kumar A, Prakash MK, et al. Estimating the herd immunity threshold by accounting for

the hidden asymptomatics using a COVID-19 specific model. PLoS One. 2020; 15: e0242132.

[9] Hayes SC, Strosahl, KD., Wilson, KG. Acceptance and commitment therapy: The process and practice of mindful change. 2nd edn. The Guilford Press: New York. 2012.

[10] Gao J, Zheng P, Jia Y, Chen H, Mao Y, Chen S, *et al*. Mental health problems and social media exposure during COVID-19 outbreak. PLoS One. 2020; 15: e0231924.

[11] Jang D, Kim I, Kwon S. Motivation and intention toward physical activity during the COVID-19 pandemic: perspectives from integrated model of self-determination and planned behavior theories. Frontiers in Psychology. 2021; 12: 714865.

[12] Vancini RL, Viana RB, Andrade MS, Lira CA, Nikolaidis PT, Almeida AA, *et al*. YouTube as a source of information about physical exercise during COVID-19 outbreak. International Journal of Sport Studies for Health. 2022; 2: e123312.

[13] Brooks SK, Webster RK, Smith LE, Woodland L, Wessely S, Greenberg N, *et al*. The psychological impact of quarantine and how to reduce it: rapid review of the evidence. The Lancet. 2020; 395: 912–920.

[14] Maugeri G, Castrogiovanni P, Battaglia G, Pippi R, D'Agata V, Palma A, *et al*. The impact of physical activity on psychological health during Covid-19 pandemic in Italy. Heliyon. 2020; 6: e04315.

[15] Meyer MN, Gjorgjieva T, Rosica D. Healthcare worker intentions to receive a COVID-19 vaccine and reasons for hesitancy: a survey of 16,158 health system employees on the eve of vaccine distribution. medRxiv. 2020.

[16] Rohmad A, Adi S. Effectiveness of online learning and physical activities study in physical education during pandemic COVID 19. Kinestetik: Journal Ilmiah Pendidikan Jasmani. 2021; 5: 64–70.

[17] Sui W, Rush J, Rhodes RE. Engagement with web-based fitness videos on youtube and instagram during the COVID-19 pandemic: longitudinal study. JMIR Formative Research. 2022; 3: 25055.

[18] Back JH, Yang JH, Hyun J. Research on the Actual Condition of Sports Activities by COVID-19 and improvements of sports activities. Journal of the Korea Convergence Society. 2020; 12: 343–351.

[19] Health plus. While we might be confined to improvised home workouts, let's make do with what's available to us, and keep these tips in mind to avoid getting injured. 2020. Available at: https://www.parkwayeast.com.sg/healthplus/article/how-to-avoid-injuries-while-doing-home-workouts (Accessed: 01 July 2020).

[20] Karen A. 10 must-follow strategies for preventing injuries while working out at home. 2020. Available at: https://www.realsimple.com/health/fitness-exercise/exercising-at-home-injury-prevention (Accessed: 01 July 2020).

[21] Davis FD. A technology acceptance model for empirically testing new end-user information systems: theory and results. Sloan School of Management, Massachusetts Institute of Technology. 1986.

[22] Davis FD, Bagozzi RP, Warshaw PR. User acceptance of computer technology: a comparison of two theoretical models. Management Science. 1989; 35: 982–1003.

[23] Ibrahim H. Technology acceptance model: extension to sport consumption. Procedia Engineering. 2014; 69: 1534–1540.

[24] Park SU, Kim DK, Ahn H. Predictive model on the intention to accept taekwondo electronic protection devices. Applied Sciences. 2021; 11: 1845.

[25] van Uffelen JGZ, Khan A, Burton NW. Gender differences in physical activity motivators and context preferences: a population-based study in people in their sixties. BMC Public Health. 2017; 17: 624.

[26] Molanorouzi K, Khoo S, Morris T. Motives for adult participation in physical activity: type of activity, age, and gender. BMC Public Health. 2015; 15: 66.

[27] Silva KS, Barbosa Filho VC, Del Duca GF, de Anselmo Peres MA, Mota J, Lopes ADS, *et al*. Gender differences in the clustering patterns of risk behaviours associated with non-communicable diseases in Brazilian adolescents. Preventive Medicine. 2014; 65: 77–81.

[28] Schorr M, Dichtel LE, Gerweck AV, Valera RD, Torriani M, Miller KK, *et al*. Sex differences in body composition and association with cardiometabolic risk. Biology of Sex Differences. 2018; 9: 28.

[29] Toselli S. Body composition and physical health in sports practice: an editorial. International Journal of Environmental Research and Public Health. 2021; 18: 4534.

[30] Karastergiou K, Smith SR, Greenberg AS, Fried SK. Sex differences in human adipose tissues—the biology of pear shape. Biology of Sex Differences. 2012; 3: 13.

[31] Rashid AT. Digital inclusion and social inequality: gender differences in ICT access and use in five developing countries. Gender, Technology and Development. 2016; 20: 306–332.

[32] Goswami A, Dutta S. Gender differences in technology usage—a literature review. Open Journal of Business and Management. 2016; 04: 51–59.

[33] Siddiq F, Scherer R. Is there a gender gap? a meta-analysis of the gender differences in students' ICT literacy. Educational Research Review. 2019; 27: 205–217.

[34] Gómez-Ruiz AA, Gálvez-Ruiz P, Grimaldi-Puyana M, Lara-Bocanegra A, García-Fernández J. Investigating the intention to use fitness app: the role of the perceived attractiveness of fitness center customers. Sport, Business and Management: an International Journal. 2022; 12: 537–553.

[35] Beldad AD, Hegner SM. Expanding the technology acceptance model with the inclusion of trust, social influence, and health valuation to determine the predictors of german users' willingness to continue using a fitness app: a structural equation modeling approach. International Journal of Human-Computer Interaction. 2018; 34: 882–893.

[36] Lee J, Lee C, Kim D. Relationship between the service quality of O2O fitness app, perceived value and flow experience: moderating effects of gender. The Korean Journal of Physical Education. 2021; 60: 403–417.

[37] König J, Jäger-Biela DJ, Glutsch N. Adapting to online teaching during COVID-19 school closure: teacher education and teacher competence effects among early career teachers in Germany. European Journal of Teacher Education. 2020; 43: 608–622.

[38] Müller AM, Alley S, Schoeppe S, Vandelanotte C. The effectiveness of e-& mHealth interventions to promote physical activity and healthy diets in developing countries: a systematic review. International Journal of Behavioral Nutrition and Physical Activity. 2016; 13: 109.

[39] Vijayasarathy LR. Predicting consumer intentions to use on-line shopping: the case for an augmented technology acceptance model. Information & Management. 2004; 41: 747–762.

[40] Venkatesh V, Davis FD. A theoretical extension of the technology acceptance model: four longitudinal field studies. Management Science. 2000; 46: 186–204.

[41] Frederick C, Ryan R. Differences in motivation for sport and exercise and their relations with participation and mental health. Journal of Sport Behavior. 1993; 16: 124–146.

[42] Weinberg R, Tenenbaum G, McKenzie A, Jackson S, Anshel M, Grove R, *et al*. Motivation for youth participation in sport and physical activity: relationships to culture, self-reported activity levels, and gender. International Journal of Sport and Exercise Psychology. 2000; 31: 321–346.

[43] Hartmann AS, Rieger E, Vocks S. Sex and gender differences in body image. Frontiers in Psychology. 2019; 10: 1696.

[44] Román ML, de la Vega R, Jiménez-Castuera R. Motivation and commitment to sports practice during the lockdown caused by Covid-19. Frontiers in Psychology. 2021; 11: 622595.

[45] Park TH, Kim WI, Park S, Ahn J, Cho MK, Kim S. Public interest in acne on the internet: comparison of search information from google trends and naver. Journal of Medical Internet Research. 2020; 22: e19427.

[46] Statistics Korea. Case in Korea. 2022. Available at: https://kosis.kr/covid_eng/covid_index.do (Accessed: 17 October 2022).

[47] Korean Ministry of Culture, Sports and Tourism. 2019 Sport white paper. 2021. Available at: https://www.mcst.go.kr/kor/s_policy/dept/deptView.jsp?pSeq=1527&pDataCD=0417000000&pType=07 (Accessed: 14 October 2022).

[48] World Health Organization (WHO). Development of the World Health Organization WHOQOL-BREF quality of life assessment The WHOQOL group. Psychological Medicine. 1998; 28: 551–558.

[49] Choi EPH, Hui BPH, Wan EYF, Kwok JYY, Tam THL, Wu C. COVID-19 and health-related quality of life: a community-based online survey in Hong Kong. International Journal of Environmental Research and Public Health. 2021; 18: 3228.

[50] Davis FD. Perceived usefulness, perceived ease of use, and user

acceptance of information technology. MIS Quarterly. 1989; 13: 319.

[51] Yu JH, Ku GCM, Lo YC, Chen CH, Hsu CH. Identifying the antecedents of university students' usage behaviour of fitness apps. Sustainability. 2021; 13: 9043.

[52] Jarvenpaa SL, Tractinsky N, Vitale M. Consumer trust in an Internet store. Information Technology and Management. 2000; 1: 45–71.

[53] Kline RB. Principles and practice of structural equation modeling. 1st ed. The Guilford Press: New York. 1998.

[54] Fornell C, Larcker DF. Evaluating structural equation models with unobservable variables and measurement error. Journal of Marketing Research. 1981; 18: 39–50.

[55] Nunnally JC, Bernstein IH. Psychometric theory. 3rd ed. MaGraw-Hill. Inc: New York. 1994.

[56] West SG, Finch JF, Curran, PJ. Structural equation models with non-normal variables: problems and remedies. In Hoyle RH (ed.). Structural Equation Modeling: Concepts, issue, and application (pp. 56–75). Sage Publications: Thousand Oaks, CA. 1995.

[57] MacCallum RC, Roznowski M, Mar CM, Reith JV. Alternative strategies for cross-validation of covariance structure models. Multivariate Behavioral Research. 1994; 29: 1–32.

[58] Byrne BM. Structural equation modeling with AMOS, EQS, and LISREL: comparative approaches to testing for the factorial validity of a measuring instrument. International Journal of Testing. 2001; 1: 55–86.

[59] United Nations news [UN news]. The impact of COVID-19 on sport, physical activity and well-being and its effects on social development. 2020. Available at: https://www.un.org/development/desa/dspd/2020/05/covid-19-sport/ (Accessed: 18 October 2022).

[60] Korea Ministry of Culture, Sports and Tourism. 2021 Korea national physical education survey. 2022. Available at: https://www.mcst.go.kr/kor/s_policy/dept/deptView.jsp?pSeq=1573&pDataCD=0417000000&pType= (Accessed: 18 October 2022).

[61] Craft BB, Carroll HA, Lustyk MK. Gender differences in exercise habits and quality of life reports: assessing the moderating effects of reasons for exercise. International Journal of Liberal Arts and Social Science. 2014; 2: 65–76.