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ORIGINAL RESEARCH

The Effect of Fitness Apps Usage Intensity on Exercise Adherence Among Chinese College Students: Testing a Moderated Mediation Model

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Purpose: With the rapid development of media network technology, college students' exercise is influenced by the use of fitness apps. How to improve the impact of fitness apps on college students' exercise is a current research hotspot. The purpose of this study was to explore the influence mechanism of fitness apps usage intensity (FAUI) on college students' exercise adherence.

Methods: A large sample of Chinese college students (N=1300) completed measures by using the FAUI Scale, Subjective Exercise Experience Scale, Control Beliefs Scale and Exercise Adherence Scale. SPSS22.0 and Hayes PROCESS macro for SPSS were used to conduct statistical analysis.

Results: (1) FAUI was positively associated with exercise adherence ($p< 0.01$); (2) Subjective exercise experience ($p<0.01$) mediated the relationship between FAUI and exercise adherence; (3) Control beliefs ($p<0.01$) moderated the relationship between FAUI and exercise adherence as well as subjective exercise experience and exercise adherence.

Conclusion: The findings reveal the correlation between FAUI and exercise adherence. Furthermore, this study is important in investigating how FAUI is related to exercise adherence in Chinese college students. The results suggest that college students' subjective exercise experience and control beliefs may be prime targets for prevention and intervention programs. Thus, this study explored "how" and "when" FAUI may enhance college students' exercise adherence.

Keywords: fitness apps, exercise experience, control beliefs, consistency in exercise, college students

Introduction

2016 "Health China 2030 Plan" stipulates that by 2030, students should exercise MVPA (Moderate to Vigorous Physical Activity) more than three times a week.[1] Adhering to long-term and regular physical exercise not only helps cultivate regular exercise habits and positive emotional experiences,[2] but also contributes to weight loss.[3] Exercise adherence is a continuous behavioural tendency exhibited by individuals in exercise.[4] Studies have found that exercise adherence has important physical and psychological effects on teenagers.[5,6]

However, the exercise behaviour of college students has been negatively affected since the COVID-19 epidemic.[7] It was found that the average exercise time of Chinese college students dropped dramatically from 540 minutes/week to 105 minutes/week during the pandemic compared to the pre-pandemic period of COVID-19.[7] The decrease in continuous physical exercise would lead to the decline of teenagers' physique and psychological resilience,[8] as well as an increase in myopia and obesity rates.[9,10] Therefore, it is necessary to investigate the primary determinants of exercise adherence and examine the underlying mechanisms.

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Fitness Apps Usage Intensity and Exercise Adherence

With the rapid development of media network technology, fitness apps become the main aid for college students to exercise.[11] However, there is less research on the impact of fitness apps on college students' exercise adherence. Fitness apps usage intensity(FAUI) refers to the degree of integration of fitness apps' social media into college students' lives.[12] According to social media theory, social media provides instrumental and emotional support and is a contributing factor to the realization of exercise behaviour.[13] With the continuous integration of modern self-media, social media is an increasingly common component of fitness apps.[12] The Study has found that fitness apps' social components (specific communities and connections to existing social media platforms) have a positive impact on promoting exercise.[14] For instance, Wang et al[15] found that the social features of fitness apps (eg, visual feedback, imitation learning, and display interaction) have a positive impact on promoting users' exercise adherence. Accordingly, we propose that FAUI may improve exercise adherence.

Subjective Exercise Experience as a Mediator

According to social media theory, FAUI may affect exercise adherence. However, Previous research has rarely explored the mechanisms mediating the effect of FAUI on exercise adherence. Researchers have suggested that it is not sufficient to simply explore the association between variables. And the introduction of mediating variables could reveal "how" FAUI affects exercise adherence.

Subjective exercise experience as a self-evaluation of emotional feelings is considered to be a mediating factor. Fitness apps are better able to guarantee the effectiveness of social interaction and emotional experience of users.[16] Through fitness apps, people could synchronize real-time dynamic data of exercise to the fitness app, share fitness experiences and achievements at any time, and supervise each other, resulting in a good emotional experience. Petersen et al[17] found that fitness apps help to enhance internal motivation such as the enjoyment experience of exercise for users. Consequently, FAUI may be associated with subjective exercise experience. Moreover, when individuals have a good subjective experience of exercise, they might believe that sports would bring practical benefits and convenience, thus increasing their willingness to participate in sports.[18] Previous researchers found that subjective exercise experience positively influenced exercise adherence.[19,20] Thus, subjective exercise experience may mediate the relationship between FAUI and exercise adherence.

The Moderating Role of Control Beliefs

FAUI may influence exercise adherence through the mediating role of subjective exercise experiences, it is undeniable that there may be some individual differences in this impact. Therefore, it is necessary to explore whether the mediating process of FAUI influence on exercise adherence through subjective exercise experience is moderated by other factors, which can help answer the question of "when does FAUI influence" to reveal the mechanism of FAUI effect on exercise adherence.

Control beliefs as a self-evaluation of behaviour and ability to influence outcomes (eg, self-control, self-efficacy and self-concept)[21] is considered to be a moderating factor. According to reciprocal determinism theory,[22] control beliefs and social media can interact as cognitive and environmental factors to influence individual behaviour. As the study found, online social self-efficacy moderated the relationship between online interpersonal trust and online altruistic behavior.[23] Khan[24] found that knowledge sharing self-efficacy moderated the relationship between knowledge-collecting behavior and social networking. Moreover, according to emotion–cognition interactions theory,[25] emotional and cognitive interactions are necessary for adaptive functioning.[25] In other words, control beliefs and emotional experiences would interact to influence individual behaviour. As the study found, decision-making self-efficacy moderated the relationship between fear of climate change and pro-environmental behaviours.[26] Wang[27] found that self-control had a moderating effect on the association between alienation and the phubbing of college students. In light of that, control beliefs may moderate the relationship between FAUI and exercise adherence, as well as the relationship between subjective exercise experience and exercise adherence.

The Present Study

Taken together, the aims of this study were threefold. First, we tested whether FAUI was significantly associated with exercise adherence. Second, the current study examined whether subjective exercise experience would mediate the relationship between FAUI and exercise adherence. Third, we tested whether control beliefs would moderate the association between FAUI and exercise adherence (Figure 1). Based on the literature review, we proposed the following hypotheses:

Hypothesis 1: FAUI is positively related to exercise adherence.

Hypothesis 2: Subjective exercise experience would mediate the relationship between FAUI and exercise adherence.

Hypothesis 3: Control beliefs would moderate the association between FAUI and exercise adherence as well as subjective exercise experience and exercise adherence.

Materials and Methods

Participants

In China's target colleges (5 ordinary colleges), 15 classes from grade 1 to grade 3 were selected through a convenience sampling method. 1705 students of the target class participated in the anonymous survey voluntarily. The criteria for unqualified participants were never using fitness apps, not answering all questions and regularity of answers, such as the same score in each item or a regular pattern of scores (1,2,3,4,5,1,2,3,4,5,1,2,3,4,5, etc.). After excluding unqualified samples, we finally collected 1300 (M_{age} =19.14, SD_{age}=1.06) valid questionnaires with an effective response rate of 76.24% from 1705 primary questionnaires. The mean age ranges from 18 to 21 years. Among them, 46.3% were boys, 53.7% were girls; 37.5% were grade 1, 27.1% were grade 2 and 35.4% were grade 3. College students and their parents provided written informed consent for this study.

Measures

Fitness Apps Usage Intensity Scale

It is a 6-item scale that was revised by Ellison et al.[28] In this study, "social networking sites" in the scale were transformed into "fitness apps". Participants rated each item (eg, When I do not use fitness apps for a while, I feel disconnected) on a 5-point scale ranging from 1= strongly disagree to 5= strongly agree. Higher scores indicate higher levels of FAUI. A confirmatory factor analysis (CFA) yielded acceptable fit indicators of Fitness Apps Usage Intensity Scale in this study: normed fit index (NFI)=0.96, goodness of fit index (GFI)=0.99, comparative fit index (CFI)=0.97, root mean square error of approximation (RMSEA)=0.05. Cronbach's alpha was 0.88. The reliability index and cultural adaptation of the scale applied in research of Chinese samples are well.[29,30]

Exercise Adherence Scale

It is a 6-item scale that was revised by Liu et al.[31] In this study, "outdoor sports" or "sports" in the scale were transformed into "exercise". Participants rated each item (eg, If I quit exercise, I will feel very sad) on a 5-point scale ranging from 1=

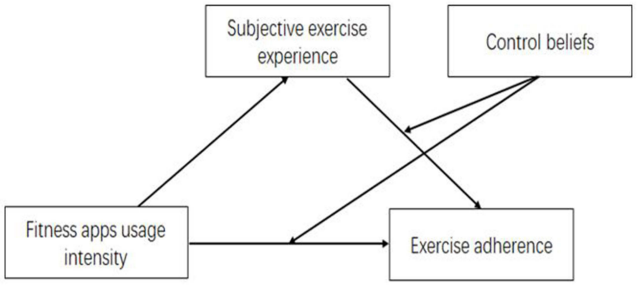

Figure 1 Moderated mediation model of the effect of FAUI on exercise adherence.

strongly disagree to 5=strongly agree. Higher scores indicate higher levels of exercise adherence. A confirmatory factor analysis (CFA) yielded acceptable fit indicators (NFI=0.97, GFI=0.99, CFI=0.98, RMSEA=0.04) of Exercise Adherence Scale in this study. Cronbach's alpha was 0.90. The reliability index and cultural adaptation of the scale applied in research of Chinese samples are well.[20,31]

Subjective Exercise Experience Scale

It is an 8-item scale that was revised by Dong.[32] Participants rated each item (eg, Taking part in exercise makes me feel confident) on a 5-point scale ranging from 1= strongly disagree to 5= strongly agree. Higher scores indicate higher levels of subjective exercise experience. A confirmatory factor analysis (CFA) yielded acceptable fit indicators (NFI=0.93, GFI=0.96, CFI=0.95, RMSEA=0.05) of Subjective Exercise Experience Scale in this study. Cronbach's alpha was 0.91. The reliability index and cultural adaptation of the scale applied in research of Chinese samples are well.[20,32]

Control Beliefs Scale

It is a 4-item scale that was revised by Marsh et al.[33] The activity self-concept represents a person's beliefs in control over regular physical activity. Participants rated each item (eg, I do physically active things at least three times per week) on a 5-point scale ranging from 1= strongly disagree to 5=strongly agree. Higher scores indicate higher levels of control beliefs. A confirmatory factor analysis (CFA) yielded acceptable fit indicators (NFI=1.0, GFI=1.0, CFI=1.0, RMSEA=0.04) of Control Beliefs Scale in this study. Cronbach's alpha was 0.84. The reliability index and cultural adaptation of the scale applied in research of Chinese samples are well.[34,35]

Procedure

To comply with the COVID-19 prevention and control policy and to minimize face-to-face contact, we distributed and collected questionnaires through Questionnaire Star (online data collection software in China) from October 10 to 20, 2022. The questionnaire clearly stated that all participants were assured that the answers were confidential. At any time, participants had the option to decline. All participants gave informed consent before data collection. Participation was voluntary and unpaid.

Statistical Analysis

Tests of normality revealed that the study variables showed no significant deviation from normality (ie, Skewness < |3.0| and Kurtosis < |10.0|).[36] Descriptive statistics were first calculated. PROCESS Models 4 and 15 macro for SPSS were used to test the mediation and moderated mediation models with 5000 random sample bootstrapping confidence intervals (CIs).[37] All variables were standardized before being analyzed.

Results

Preliminary Analyses

As shown in Table 1. FAUI was positively correlated with subjective exercise experience, exercise adherence and control beliefs. Subjective exercise experience was positively correlated with exercise adherence and control beliefs. Exercise adherence was positively correlated with control beliefs. Therefore, Hypothesis 1 was supported.

Testing for Mediation Effect

We used Model 4 of the SPSS macro PROCESS to test hypothesis 2. The regression results for testing mediation are reported after controlling covariates in Table 2. Results indicated that FAUI was positively related to subjective exercise experience (β= 0.22, $p < 0.01$, 95% *CI* [0.17, 0.27]) and exercise adherence (β= 0.46, $p < 0.01$, 95% *CI* [0.41, 0.51]). The residual direct effect of FAUI on exercise adherence remained positive (β= 0.36, $p < 0.01$, 95% *CI* [0.32, 0.41]). These results show that subjective exercise experience partially mediated the association between FAUI and exercise adherence (indirect effect = 0.10, *SE* = 0.01, 95% *CI* [0.07, 0.12]), and the mediation effect accounted for 21.74% of the total effect of FAUI on exercise adherence. Therefore, Hypothesis 2 was supported.

Table 1 Descriptive Statistics and Correlations Among Variables

	M±SD	1	2	3	4	5	6	7	8	9
1. Gender	0.46±0.50	1								
2. Grade	1.98±0.86	0.07*	1							
3. Registered residence	0.58±0.49	0.02	0.08**	1						
4. Income of households	3.88±1.58	0.07*	0.01	−0.25**	1					
5. Physical fitness test	3.06±1.01	−0.14**	−0.09**	0.05	0.03	1				
6. FAUI	16.27±5.19	−0.03	0.10**	0.05	0.01	0.19**	1			
7.Subjective exercise experience	30.30±5.50	0.13**	−0.05	−0.05	0.08**	0.22**	0.25**	1		
8. Exercise adherence	18.79±4.84	0.17**	0.03	0.03	0.06*	0.23**	0.49**	0.56**	1	
9. Control beliefs	13.06±3.56	0.15**	0.16**	0.06*	0.05	0.20**	0.38**	0.42**	0.60**	1

Notes: *p<0.05; **p<0.01.

Table 2 Linear Regression Models

Predictors	**Model1(SEE)**		**Model2(EA)**		**Model3(EA)**		**Model4(EA)**	
	β	**t**	***β***	**t**	***β***	**t**	***β***	**t**
Gender	0.16	6.17**	0.20	8.62**	0.13	6.32**	0.09	4.59**
Grade	−0.06	−2.19*	−0.02	−0.74	0.01	0.39	−0.04	−1.92
Registered residence	−0.05	−2.01*	0.01	0.29	0.03	1.46	0.01	0.74
Income of households	0.05	1.74	0.04	1.51	0.02	0.75	0.01	0.65
Physical fitness test	0.20	7.33**	0.17	7.21**	0.09	4.06**	0.05	2.35*
FAUI	0.22	8.31**	0.46	19.36**	0.36	17.08**	0.29	14.19**
SEE					0.44	20.25**	0.34	15.97**
Control beliefs							0.31	13.67**
FAUI×Control beliefs							−0.08	−4.41**
SEE×Control beliefs							0.08	4.85**
R^2	0.13		0.3		0.47		0.56	
F	31.5**		93.01**		163.5**		164.41**	

Notes: *p < 0.05, **p < 0.01.
Abbreviations: FAUI, fitness apps usage intensity; SEE, subjective exercise experience; EA, exercise adherence.

Moderated Mediation Effect Analysis

We used model 15 in SPSS macro PROCESS to test hypothesis 3. The results are presented in Table 2. The moderated mediation model showed that FAUI was positively associated with exercise adherence (β= 0.29, p < 0.01, 95% *CI* [0.25, 0.34]), while subjective exercise experience was positively associated with exercise adherence (β= 0.34, p < 0.01, 95% *CI* [0.29, 0.38]). Furthermore, the predictive effects of the interaction of FAUI and control beliefs (β=−0.08, p < 0.01, 95% *CI* [−0.12, −0.04]) was significant, as well as the interaction of subjective exercise experience and control beliefs for exercise adherence (β= 0.08, p < 0.01, 95% *CI* [0.05, 0.12]). These results indicated that control beliefs could moderate the associations between FAUI and exercise adherence, as well as the associations between subjective exercise experience and exercise adherence. Therefore, Hypothesis 3 was supported. The interaction effect is visually plotted in Figure 2. Simple slope tests showed that for college students with low control beliefs, FAUI significantly predicted exercise adherence, b_{simple} = 0.38, t = 12.38, p < 0.01. However, for college students with high control beliefs, FAUI significantly predicted exercise adherence but much weaker, b_{simple} =0.21, t = 8.62, p < 0.01, indicating a weakening effect of control beliefs. Lastly, the interaction effect is visually plotted in Figure 3. Simple slope tests showed that subjective exercise experience significantly predicted exercise adherence in high-level control beliefs and low-level control beliefs, but the predictive function of subjective exercise experience on exercise adherence was stronger for

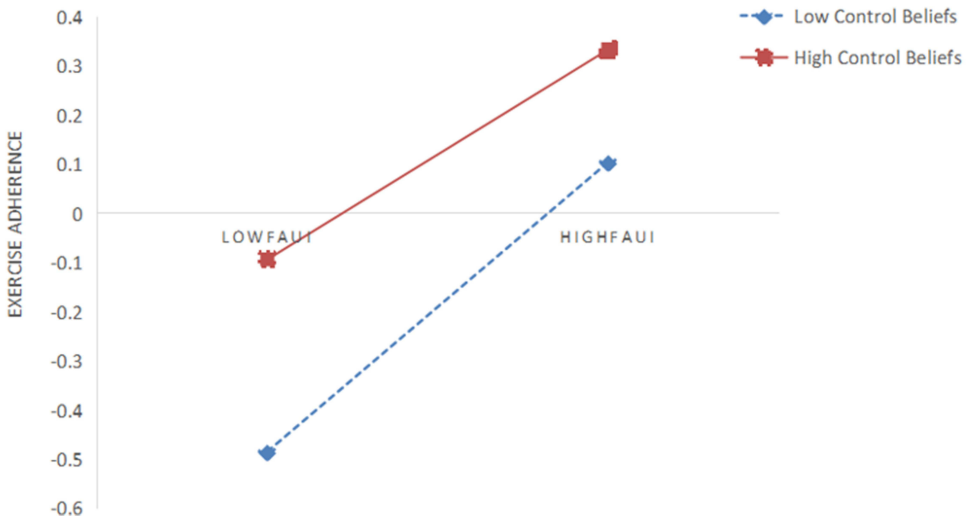

Figure 2 Interaction effect of FAUI with control belief.
Abbreviation: FAUI, fitness apps usage intensity.

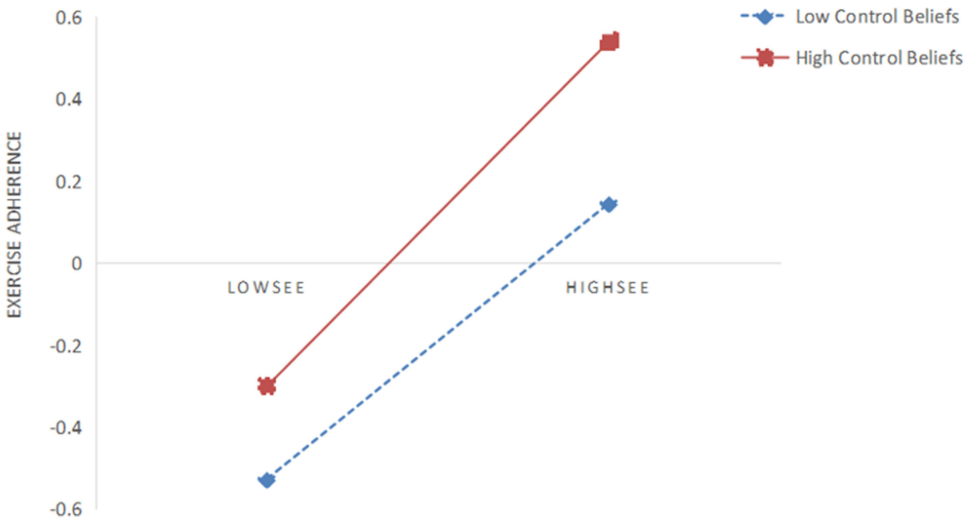

Figure 3 Interaction effect of SEE with control belief.
Abbreviation: SEE, subjective exercise experience.

college students with high levels of control beliefs (b_{simple} = 0.42, t = 15.17, p < 0.01) than for college students with low levels of control beliefs (b_{simple} = 0.25, t = 9.40, p < 0.01), indicating an enhancing effect of control beliefs.

The bias-corrected percentile bootstrap analysis further indicated that the indirect effect of FAUI on exercise adherence through subjective exercise experience was moderated by control beliefs. Particularly, for college students high in control beliefs, the indirect effect of FAUI on exercise adherence via subjective exercise experience was significant, β= 0.09, SE = 0.01, 95% CI [0.07, 0.12]. The indirect effect was also significant for college students with low control beliefs, but weaker, β= 0.06, SE = 0.01, 95% CI [0.04, 0.08].

Discussion

This study constructed a moderated mediation model of the effect of FAUI on exercise adherence. The results showed that FAUI was positively associated with exercise adherence, and subjective exercise experience played a mediating role between FAUI and exercise adherence. Moreover, control beliefs played a moderating role between FAUI and exercise adherence as well as between subjective exercise experience and exercise adherence.

The Relationship Between FAUI and Exercise Adherence

The positive impact of FAUI on exercise adherence might be largely attributed to the unique capabilities of specific app communities and current social media platforms.[38] Students who use those social components on fitness apps have a good peer relationship of active communication and mutual encouragement among them,[39] instead of the zero-sum competition.[40,41] In processes of exercise demonstration via media, they can feel the care, support and understanding from their peers on social media,[40,42] and have a sense of belonging to the community constituted by student users of fitness apps.[16,43] Based on the theory of self-determination and social media theory, as the psychological needs of autonomy, belonging and competence are satisfied by such social media technology and its accompanying community relationships,[44,45] student users have stronger interests in exercising. Hence, their exercise behaviours can be more sustained and frequent.[44]

The Mediating Role of Subjective Exercise Experiences

The mediation effect test showed that subjective exercise experience mediated the relationship between FAUI and exercise adherence. According to environmental perception theory, people's perception and understanding of their environment (social network of fitness apps) internalize discriminative information about the behavioural environment, which stimulates emotional experiences and guides behavioural practices.[46,47] As a virtual environment, the interactive community of fitness apps provides a platform for college students to express their exercise experience.[40,44] Along with the deepening interaction, they release and share more emotional experiences that they dare not express in reality through the virtual community.[40,42] Meanwhile, when these emotional experiences are validated and supported by other users, they will engender positive emotions.[48] This emotion could provide essential clues for exercising the cognitive system of memory and stimulate the desire to repeat the exercise to satiate the emotional experience.[49]

The Moderating Role of Control Beliefs

This study found that control beliefs moderated the relationship between FAUI and exercise adherence. Specifically, the effect of FAUI on exercise adherence diminished as control beliefs increased. The study finds that increasing the levels of FAUI can promote college students' exercise adherence with low levels of control beliefs. According to the theory of self-determination.[50] Encouragement and attention from fitness apps mostly reflect external motivational beliefs and control beliefs mostly reflect internal motivational beliefs. However, internal motivation with more autonomy is the proximal determinant of individual behaviour.[50] It indicates from the side that the better control beliefs of college students lead to more autonomy and self-determination, followed by more sustained exercise.[19,51]

In addition, this study found that control beliefs moderated the relationship between subjective exercise experience and college students' exercise adherence. Specifically, the effect of subjective exercise experience on exercise adherence increased with the enhancement of control beliefs. The study finds that increasing the levels of subjective exercise experience can promote college students' exercise adherence with high levels of control beliefs. According to the control emotion theory, physical activity self-concept is an important indicator for evaluating control beliefs.[21] Dual systems theory suggests that physical activity self-concept plays an important role in the process of contextual cues, automatic affective evaluations, and physical activity associations.[52] When a situational cue activates an individual's physical activity self-concept, its associative memory is easily activated, and this activation is transmitted in a networked form to closely associated nodes (eg, characteristic affective experiences) subsequently.[53] As valid self-evaluations are generated, the likelihood of individuals participating in exercise increases.

Limitations

This study also has some limitations that need to be noted. Firstly, this study used a cross-sectional design, which could not provide evidence of causality. Secondly, this study used only self-report questionnaires as a source of research data for college students, which may be subject to social desirability bias. Thirdly, this study focused on college students, and more research is needed to explore whether the results apply to other samples, such as adults and adolescents.

Despite these limitations, contributions from the current study are both theoretical and practical. From a theoretical point of view, this study extends previous studies by emphasizing the mediating role of subjective exercise experience, as well as the moderating role of control beliefs. Our study contributes to the research understanding of the association between FAUI and college students' exercise adherence. From a practical point of view, college departments should make use of fitness apps to promote college students' participation in exercise and focus on stimulating the emotional interaction of communities to enhance emotional experiences. Lastly, it should also consider the individual differences of students in control beliefs, and provide differentiated social network functions for college users with different control beliefs.

Conclusions

In summary, FAUI was significantly and positively associated with exercise adherence. This study is important in investigating how FAUI is related to exercise adherence of Chinese college students, even if further replication and extension are needed. Subjective exercise experience mediates the relationship between FAUI and exercise adherence. The focus on subjective exercise experience provides additional nuances in linking FAUI to college students' exercise adherence. Furthermore, this mediation mechanism is moderated by control beliefs. The results suggest that college students' subjective exercise experience and control beliefs may be prime targets for prevention and intervention programs. Thus, this study explored "how" and "when" FAUI may enhance college students' exercise adherence.

Data Sharing Statement

The authors will make all raw data supporting their results freely accessible, and the corresponding author/s can be directly contacted for further inquiry.

Ethics Statement

The study was approved by the Ethics Committee of College of Physical Education at Central China Normal University. Written informed consent was obtained from all participants. The authors declared no potential conflict of interest with the students as participants. The guidelines outlined in the Declaration of Helsinki were followed.

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Disclosure

The authors report no conflict of interest in this work.

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