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Exploring the Impact of eHealth Literacy on Appearance-related Sociocultural Pressure Among Female Undergraduates: A moderated mediation model

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Article

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Abstract

This study aims to examine the relationship between eHealth literacy (eHL) and appearance-related sociocultural pressure(ARSP) among female undergraduates, while analyzing the mediating role of mobile phone addiction(MPA) and the moderating effect of physical exercise(PE). A cross-sectional survey was conducted among 950 female students from three Chinese colleges using the following validated scales: the eHealth Literacy Scale(eHLS), Mobile Phone Addiction Scale(MPAS), Physical Activity Rating Scale(PARS) and Sociocultural Pressure Scale(SPS). After controlling for age, grade, and geographical origin, the results showed that: (1) eHL had a significantly negative effect on female college students' ARSP; (2) MPA mediated the relationship between eHL and ARSP, accounting for 29.7% of the total effect; (3) PE significantly moderated the relationships between eHL and ARSP, between MPA and ARSP, and between eHL and MPA. This study contributes to revealing the relationship between eHL and ARSP among Chinese female undergraduates, providing important implications for the prevention and intervention of ARSP.

Introduction

Appearance-related sociocultural pressure(ARSP) is a specific manifestation of sociocultural pressure in the domain of appearance aesthetics. It describes the specific pressure that individuals perceive from social communication agents such as family, friends, and the media, with its core orientation being to require individuals to conform to the ideal appearance standards within a cultural context [1]. As a common source of negative emotional experience, this form of pressure can lead to various degrees of mental health issues and behavioral problems. Studies indicated that ARSP not only heightens the risk of low self-esteem[2], anxiety, and depression[3], but also contributes to eating disorders[4] and other weight control behaviors[5]. Notably, in the era of open media environment and amid the rapid growth of beauty and cosmetic surgery industry, specific facial features such as high nose bridges, double eyelids, and slender bodies have increasingly become exclusive aesthetic standards for women. This phenomenon makes women particularly susceptible to sociocultural pressures rooted in bodily stereotypes[6]. Meanwhile, teasing from family members and peers—especially comments about weight or skin tone—can significantly worsen body image dissatisfaction among adolescent girls[7,8]. Previous studies indicated that ARSP are most prevalent during young womanhood, with female college students and adolescent girls being at particularly high risk[9,10]. Therefore, it is essential to thoroughly examine the factors influencing ARSP among female undergraduates, as well as the mechanisms through which these factors operate.

- The stress-buffering hypothesis posits that positive personal traits can lessen the potential negative impact of stress on mental health[11]. As key components for health promotion, eHL and PE can enhance individual resilience and relieve stress through various pathways such as information empowerment, social support, physiological regulation, and psychological motivation. Beyond these factors, social networking platforms, which are key elements of the external environment, are also significantly associated with individuals' experiences of sociocultural pressure[12,13]. Therefore,

when exploring the multifaceted formation of ARSP among female undergraduates, it is important to consider MPA (which is a common behavioral manifestation of social network dependence) as a key influencing factor. In summary, given the multidimensional negative impact of ARSP on female college students' physical and mental health, this research aims to examine its formation by investigating the combined impacts of eHL and PE (as health-promoting behaviors) and MPA (as an external influencing factor). This is of great significance for preventing and intervening in their ARSP.

- eHealth literacy (eHL) indicates an individual's capacity to search for, comprehend, and assess health information through digital media, actively engage in health information exchange, and apply this knowledge in managing health and solving related problems[14]. It reflects an individual's ability to make effective use of digital health resources. Studies indicate that a higher level of eHL contributes positively to individuals' mental well-being and health-related behaviors[15]. According to the tripartite influence model, body image is mainly affected by three sociocultural factors: media, family, and peers[16]. These agents perpetuate idealized appearance norms through various channels, heightening individuals' sensitivity to and internalization of ARSP[17]. Relevant research suggested that individuals with a higher level of e-health literacy are more inclined to seek health information online[18], which enhances their understanding and decision-making regarding health behaviors[19], thereby mitigating negative emotions—such as anxiety, stress, and self-doubt caused by poor body image as much as possible[20]. In other words, individuals with a lower level of eHL may struggle to differentiate credible health information from conflicting content on social media[21]. This is more likely to lead to the uncritical acceptance of socially promoted, irrational beauty standards, such as the "A4 waist" or "abdominal muscles", thereby increasing stress and other negative emotional responses. Given the above findings, it is plausible to consider high eHL as a key protective factor against ARSP. Accordingly, Hypothesis 1 is proposed: eHL can negatively predict ARSP among female undergraduates.

Mobile phone addiction (MPA) is a newly emerging form of behavioral addiction, caused by excessive dependence on smartphones and prolonged use, which leads to various psychological and behavioral issues[22]. Such problematic behavior not only indicates impaired self-regulation, but is also strongly associated with serious mental health concerns[23]. Studies indicated that excessive smartphone use encourages individuals to internalize socially idealized body standards, which in turn lower their physical self-esteem[24]. According to Social Comparison Theory, individuals have an inherent need for self-evaluation and for establishing standards against which to assess themselves; however, the social environment often lacks clear and objective benchmarks for such evaluations[25]. In this context, social networking websites fulfill this need for social comparison by offering access to others' lives beyond spatial and temporal boundaries[26]. Studies revealed that prolonged engagement with social media can satisfy users' psychological needs, potentially fostering addictive behaviors[27]. Meanwhile, the internal drive for self-evaluation amplifies the tendency for social comparison, leading individuals to internalize external appearance standards as subjective aesthetic references[28]. Many studies indicated that appearance comparisons on social network platforms, as opposed to other settings, are more strongly associated with negative body image[29,30]. Furthermore, the risk-buffering model suggests that

protective factors can mitigate or reduce the negative impact of risk factors on individuals[31]. Individuals who have higher eHL can obtain and assess health information more efficiently, and engage in proactive self-regulation when confronting problematic behaviors to buffer its negative impact. Empirical evidence suggests that those individuals who have higher eHL tend to spend less time on online games[32]. Conversely, individuals who have lower eHL often demonstrate poorer self-regulation skills[33] and are more susceptible to excessive or uncontrolled mobile phone use, which in turn may heighten the risk of addiction. Therefore, drawing on the aforementioned theories and empirical findings, Hypothesis 2 is proposed: MPA serves as a mediator in the relationship between eHL and ARSP.

Physical exercise (PE) is a form of physical activity carried out with specific intensity, frequency, and duration, designed in response to individual physical and health needs, it promotes both physical and mental health, while also helping to regulate psychological well-being[34]. As a key strategy for enhancing health, PE plays an important role in improving mood, supporting cognitive development, and reducing mental health problems[35].For example, PE has been found to be significantly associated with internalizing and externalizing problems, as well as with cognitive reappraisal[36]. Empirical research indicated that PE helps reduce mobile phone dependence[37], with moderate-intensity exercise being more effective than high-intensity exercise in mitigating such dependence among college students[38]. Similarly, engaging in PE can not only directly enhance one's physical appearance[39], but also help alleviate appearance anxiety by reducing self-objectification [40]. These findings suggested that PE might serve as a protective factor against ARSP. As previously noted, eHL is also a protective factor in reducing ARSP. The enhancement hypothesis within the Protective Factor–Protective Factor Model suggests that one protective factor can magnify the impact of another on outcome variables[41]. Based on this hypothesis, it is reasonable to infer that PE may strengthen the negative predictive effect of eHL on MPA and ARSP among female undergraduates. In other words, among female undergraduates who have higher levels of PE, improvements in eHL might be associated with lower risks of MPA and ARSP. Moreover, according to the Uses and Gratifications Theory, individuals' specific psychological needs can be fulfilled through various online activities. This positive reinforcement mechanism encourages more frequent use of digital devices, and over time, such patterns may contribute to the development of mobile phone dependency[42]. However, individuals who engage in regular PE are more likely to satisfy psychological needs such as autonomy and physical competence through offline means, thereby reducing their time spent on social media[43]. This not only decreases their exposure to and internalization of weight loss-related content online, but also helps prevent the emergence of slimming tendencies and appearance-related anxiety caused by excessive exposure to body image information on the internet[44]. Given this, it can be inferred that frequent PE can weaken the positive predictive relationship between MPA and ARSP among female undergraduates. In other words, for female undergraduates who have higher levels of PE, lower levels of phone addiction are likely to be associated with reduced ARSP. Accordingly, this study proposes Hypothesis 3: PE moderates both the mediated and direct pathways that link "eHL, MPA, and ARSP".

In a nutshell, this study intends to examine the relationship between eHL and ARSP among female undergraduates. Special attention is given to the roles of MPA and PE in this process, aiming to offer

targeted recommendations for effective prevention and intervention strategies. A hypothetical model is proposed, as shown in Fig. 1.

Research Design

- Participants and Experimental Procedures

With the convenience sampling method, we collected online data from 1,015 female undergraduates across four Chinese colleges via the Questionnaire Star platform. Questionnaires were screened based on response duration, duplicate submissions, and basic information inconsistencies (e.g., age discrepancies), yielding 950 valid responses with a 94% validity rate.The participant cohort exhibited the following demographic characteristics: Age distribution comprised 534 students (56.2%) aged 19 or younger, 240 (25.3%) aged 20, 99 (10.4%) aged 21, 74 (7.8%) aged 22, and 3 (0.3%) aged 23 or older. By academic year, the sample included 597 freshmen (62.8%), 174 sophomores (18.3%), 63 juniors (6.6%), and 116 seniors (12.2%). Regarding family structure, 146 participants (15.4%) were only children while 804 (84.6%) had siblings. Disciplinary backgrounds comprised 373 humanities majors (39.3%) and 577 STEM majors (60.7%).

This research received approval from the Science and Technology Department of Beijing Youth Political College, and all procedures were conducted in full compliance with relevant local laws, regulations, and institutional ethical guidelines.

Research Tools

eHealth Literacy Scale (eHLS)

The Chinese version of the eHL Scale revised by Guo et al. (45) was used in this study. The scale consists of 8 items, such as “I know how to use information obtained from online health resources to help myself.” A 5-point Likert scale was adopted, and eHL level is positively correlated with the total score. In this study, Cronbach’s α is 0.965.

Sociocultural Pressure Scale (SPS)

The study adopted the Sociocultural Pressure Scale(46), which was used to assess externally imposed appearance-related pressure perceived by individuals from familial, peer, and media sources. It consists of 8 items, such as “I feel pressure from my friends to change my physical appearance.” Since its items all reflect sociocultural pressures related to an individual's appearance, this study used it to measure the ARSP experienced by female college students. A 5-point Likert scale was adopted, and ARSP level is positively correlated with the total score.In this study Cronbach's α is 0.943.

Mobile Phone Addiction Scale(MPAS)

The study adopted the College Students Mobile Phone Addiction Scale(47), which comprises 16 items such as “I feel uncomfortable if I haven’t used my phone for a long time.” A 5-point Likert scale was adopted, and the level of MPA increases as the individual's total score rises, In this study, Cronbach’s α was 0.939.

Physical Activity Rating Scale (PARS)

The study adopted the Chinese version of the Physical Activity Rating Scale revised by Liang (48). This scale assesses physical activity across three dimensions: intensity (e.g., high-intensity continuous exercises such as running or swimming that cause shortness of breath and heavy sweating), duration (e.g., more than 60 minutes), and frequency (e.g., about once per day). Each dimension is rated on a 5-point scale (1–5). The total PE score is calculated as: frequency × (duration − 1) × intensity. In this study, Cronbach’s α was 0.739.

- Research Procedure

First, upon securing informed consent from college students and their institutions, well-trained faculty and student researchers served as principal examiners for the classroom-administered questionnaire, during which standardized instructions were provided to specify survey content and response requirements. Subsequently, the data were analyzed in SPSS 26.0 for descriptive and inferential statistics. Moderated mediation analysis was conducted using the PROCESS macro with bootstrapping (5,000 resamples) to estimate conditional indirect effects at varying levels of the moderator.

Results and Analysis

- Common method Bias

Given that all variables in this study were derived from self-reported data of female college students, potential common method bias necessitated evaluation. Harman's single-factor test was therefore applied, with exploratory factor analysis performed on all variables. Results identified the extraction of six factors with eigenvalues exceeding 1, and the variance explained by the initial factor stood at 36.44%—a value below the 40% cutoff. This outcome confirms that common method bias does not pose a notable problem for the present study.

Descriptive Statistics and Correlation Analysis

The means of various variables, standard deviations, and correlation matrix are listed in Table 1. Correlation analyses revealed statistically significant associations among eHL, MPA, PE, and ARSP.

Table 1
The means, standard deviations, and correlation coefficients of the variables.

Variable	M ± SD	PE	ARSP	MPA	eHL
PE	7.58 ± 9.836	1			
ARSP	18.76 ± 6.101	-0.291**	1		
MPA	43.08 ± 10.71	-0.313**	0.444**	1	
eHL	27.83 ± 6.394	0.300**	-0.375**	-0.312**	1
Note: *P<0.05, **P<0.01, ***P<0.001, This is also applicable to the table below.					
Analysis of Mediating Effect Analysis					

Table 2
Analysis of the mediating effect of MPA.

	ARSP		ARSP		MPA	
	β	t	*β*	t	*β*	t
Age	0.326	1.095	0.302	0.942	-0.120	-0.207
Grade	-0.297	-1.080	-0.365	-1.233	-0.329	-0.619
Geographical origin	-0.389	-1.009	-0.371	-0.895	0.088	0.117
Only children	-0.310	-0.641	-0.497	-0.954	-0.908	-0.970
Major	-0.268	-0.760	-0.456	-1.204	-0.918	-1.347
eHL	-0.251	-8.877***	-0.356	-12.338***	-0.516	-9.930***
MPA	0.205	12.172***				
R^2	0.2617		0.1456		0.1021	
F	47.7034		26.7812		17.8789	
Note: All variables in the model are substituted with standardized data, the same blow.						

This study examined the role of MPA in mediating the relationship between eHL and ARSP using Model 4 of Hayes' SPSS PROCESS macro. The results demonstrated (see Table 2) that eHL exerted a significantly negative predictive effect on ARSP (β=-0.356, t=-12.338, P□0.001). These findings suggest that eHL can mitigate ARSP among female undergraduates, thereby supporting Hypothesis 1. When MPA was incorporated into the regression equation, eHL demonstrated a significantly negative predictive effect on MPA (β=-0.516, t=-9.930, P□0.001). Moreover, MPA exerted a significantly positive predictive effect on ARSP (β = 0.205, t = 12.172, P□0.001). These results further confirm the role of MPA in mediating the relationship between eHL and ARSP.

In addition, Bootstrap mediation analysis (see Table 3) revealed that for the direct effect, the 95% confidence interval for the association between eHL and ARSP was [-0.311, -0.192], it does not include 0. The results suggest that eHL is a significant negative predictor of ARSP, with a standardized effect size of -0.251, explaining 70.3% of the total direct effect. For the mediating effect, the 95% confidence interval for MPA was [-0.139, -0.075], and it also excluded 0, indicating a significant mediating role of MPA in the relationship between eHL and ARSP, with an effect size of -0.106, accounting for 29.7% of the total effect. The established mediation effect demonstrated that eHL not only directly and negatively predicts ARSP among female undergraduates, but also indirectly predicts it through MPA, thereby supporting Hypothesis 2.

Table 3
Bootstrap analysis for the significance test of the mediating effect.

MPA	**Effect**	**BootSE**	**BootLLCI**	**BootULCI**	**Relative effect ratio**
	-0.106	**0.016**	**-0.139**	**-0.075**	**29.7%**
Direct effect	-0.251	0.030	-0.311	-0.192	70.3%
Total effect	-0.356	0.031	-0.419	-0.298	100%
Test of Moderated Mediation Model					

Table 4
Test of moderated mediation model.

	MPA				ARSP			
	β	**t**	**LLCI**	**ULCI**	**β**	**t**	**LLCI**	**ULCI**
Age	0.297	0.530	-0.802	1.396	0.439	1.485	-0.141	1.019
Grade	-0.466	-0.904	-1.476	0.545	-0.361	-1.328	-0.895	0.173
Geographical origin	-0.096	-0.134	-1.513	1.320	-0.427	-1.121	-1.175	0.321
Only children	-1.282	-1.415	-3.060	0.496	-0.481	-1.003	-1.421	0.459
Major	-0.590	-0.892	-1.890	0.709	-0.220	-0.629	-0.906	0.466
eHL	-0.436	-8.138***	-0.541	-0.331	-0.251	-8.517***	-0.309	-0.193
PE	-0.195	-4.885***	-0.273	-0.117	-0.073	-2.986**	-0.121	-0.025
eHL x PE	-0.021	-3.379***	-0.033	-0.009	-0.014	-3.534***	-0.022	-0.006
MPA					0.179	10.303***	0.145	0.213
MPA x PE					-0.005	-2.138*	-0.010	0.000
R^2	0.164				0.284			
F	23.027				37.190			

A moderated mediation analysis was conducted. Model 59 was employed to test a moderated mediation model, taking eHL as the independent variable, ARSP as the dependent variable, MPA as the mediator, and PE as the moderator. As presented in Table 4 and Fig. 2, the interaction term between eHL and PE demonstrated significantly negative predictive effects on both MPA (β= -0.021, t= -3.379, P<0.05) and ARSP (β= -0.014, t= -3.534, P<0.05). The interaction term between MPA and PE demonstrated a significantly negative predictive effect on ARSP (β= -0.005, t=-2.138, P<0.05), thereby confirming Hypothesis 3.

Further simple slope analysis of the first-stage mediation pathway (see Fig. 3) revealed that for female undergraduates with lower PE scores (M − 1SD), eHL showed a significantly negative effect on MPA (*simple slope*= -0.279, t=-4.405, P<0.001). For female undergraduates with higher PE scores (M + 1SD), eHL similarly demonstrated a significantly stronger negative effect on MPA (*simple slope*=-0.640, t=-7.235, P<0.001). This suggests that the negative predictive effect of eHL on MPA becomes stronger when the level of PE increases. Analysis of the second-stage mediation pathway (see Fig. 4) demonstrated that for female undergraduates with lower PE scores (M − 1SD), MPA demonstrated a significantly positive predictive effect on ARSP (*simple slope* = 0.217, t = 9.234, P<0.001). Among female undergraduates with higher PE scores (M + 1SD), MPA still showed a significantly positive, though weak, association with ARSP (*simple slope* = 0.128, t = 4.155, P<0.001). This indicates that when the level of PE

increases, the predictive effect of mobile addiction on ARSP gradually decreases. In the direct pathway (see Fig. 5), for female undergraduates with lower PE scores (M − 1SD), eHL similarly demonstrated a significantly negative effect on ARSP (*simple slope*= -0.143, t=-3.868, P<0.001). For female undergraduates with higher PE scores (M + 1SD), eHL similarly demonstrated a significantly stronger negative effect on ARSP(*simple slope*=-0.391, t=-7.122, P<0.001). This indicates that as the level of PE increases, the negative predictive effect of eHL on ARSP tends to strengthen.

Discussion

eHL and ARSP Among Female Undergraduates

The findings of this study indicate that eHL is a significant negative predictor of ARSP pressure among female undergraduates, supporting Hypothesis 1. This result aligns with previous studies, showing that eHL positively correlates with college students' emotional regulation skills[49]. This complies with the Integrative Model of E-Health Use, which suggests that individuals with high levels of eHL can better identify and avoid harmful health information[50], and are more likely to engage in scientifically grounded and proactive health behaviors[51]. eHL helps maintain and promote a positive mental health state, and significantly reduces the risk of various negative psychological effects[52]. In the context of this study, female undergraduates with higher eHL show a clear advantage in coping with ARSP[53]. They are not only capable of effectively accessing and evaluating eHealth information, but also of critically understanding the underlying mechanisms and commercial intent behind media content. When confronted with perfect body ideals promoted by family, peers, and mass media, they are able to evaluate these standards rationally using scientific indicators such as body fat percentage and BMI, thereby developing a more balanced and informed body image perception[54]. This comprehensive competence allows female undergraduates to actively reshape their social comparison strategies, moving away from upward comparisons with idealized standards toward healthier parallel comparisons (with similar peers) or downward comparisons (emphasizing examples of body diversity). In doing so, they strengthen body acceptance and psychological well-being, while mitigating the internalized ARSP—perceived through media, family, and peer influences—to align with culturally constructed ideals of physical appearance.

- The Mediating Effect of MPA

The findings of this study indicate that MPA serves as an intermediary between eHL and ARSP among female undergraduates. Higher levels of eHL can curb MPA tendencies among female undergraduates, thereby easing their perceived ARSP. This finding supports Hypothesis 2. On the one hand, eHL functions as a protective factor and shows a significant negative correlation with MPA among female undergraduates. This result aligns with the risk-buffering model, suggesting that eHL can offset or lessen the negative impacts of MPA on individuals. Studies have found that, compared to male undergraduates, female undergraduates are more proactive in seeking online health information, which enables them to acquire a broader range of health-related knowledge[55]. Female undergraduates with

higher e-health literacy tend to have a clearer awareness of the potential risks that excessive mobile phone use poses to sleep quality, emotional stability, and mental health. With improved health awareness and skills, female undergraduates are more likely to adopt proactive coping strategies—such as setting screen time limits[56], including setting time limits for mobile phone use, cultivating alternative health habits and other behavioral intervention measures. Conscious self-regulation not only helps limit phone use in terms of duration and frequency, but more importantly, conserves limited self-control resources and prevents loss of control caused by prolonged self-depletion, ultimately lowering the risk of MPA. On the other hand, MPA—as a risk factor—is significantly and positively associated with ARSP among female undergraduates. This finding aligns with results from previous studies [10] and supports the social comparison theory. According to the findings of this study, when female college students spend extended periods browsing short videos and social media content, platform algorithms tend to repeatedly recommend content that reflects mainstream beauty ideals, such as a “slap face”“chopstick legs” or an “A4 waist”. Prolonged exposure to such content may lead them to internalize prevailing beauty standards[57], thereby placing increasing importance on physical appearance in their overall sense of self-worth. In this process, female undergraduates are likely to engage more frequently and intensely in upward appearance comparisons, which in turn amplifies body dissatisfaction—manifesting in feelings such as not being slim or fair-skinned enough[58]. Such enduring negative self-perceptions often trigger psychological defense mechanisms, leaving them in a prolonged state of stress.

The Moderating Role of PE

The findings of this study indicate that PE significantly moderates the relationships between eHL and ARSP, eHL and MPA, MPA, and ARSP. These findings support Hypothesis 3. On the one hand, as PE levels increase, eHL becomes a stronger negative predictor of both MPA and ARSP among female college students. This finding supports the facilitation hypothesis of the "protective-protective factor model." In particular, female students who regularly engage in PE often develop self-discipline through consistent training routines and efforts to improve body posture, gaining a sense of accomplishment throughout the process of goal attainment. This not only helps sustain long-term exercise habits(59) but also significantly enhances their sense of self-efficacy[60]. Motivated by this process, female college students tend to actively seek out health-related information: they systematically acquire knowledge from authoritative sources such as PubMed and the official website of the World Health Organization (WHO), and they use fitness apps and wearable smart devices to monitor metrics like step count, heart rate, and sleep quality. Over time, this fosters a habit of scientifically managing personal health through digital tools[61]. This sustained health practice improves their ability to access, evaluate, and apply digital health information, thereby strengthening eHL. Notably, college students who regularly engage in PE tend to use smartphones more as tools for health management than for entertainment[62], thus effectively reducing the risk of addiction caused by passive use of mobile phones. By critically reflecting on idealized appearance norms—such as the "perfect body"—promoted by social media and peer groups, female students who engage in PE regularly can ease anxiety and reduce the pressure to conform to socioculturally constructed beauty ideals. On the other hand, PE weakens the predictive effect of MPA on

ARSP. This finding aligns with results from previous studies[63]. A possible explanation is that regular exercise effectively replaces the time that might otherwise be spent passively scrolling through smartphones, thereby mitigating addictive behaviors caused by non-purposeful phone use. From a physiological standpoint, PE enhances the structure and function of specific regions in the central nervous system and modulates dopamine activity and receptor sensitivity. These effects help correct behavioral addictions such as mobile phone dependency[64]. Consequently, exercise reduces female students' exposure to irrational beauty standards (such as the "ideal face" or "perfect figure") amplified by social media algorithms, leading to less upward social comparison and, ultimately, lower pressure. This contributes to healthier self-perception and psychological adjustment.

Research Significance and Limitations

This study developed and tested a moderated mediation model involving eHL, MPA, PE, and ARSP, revealing the underlying mechanism linking eHL and ARSP among female undergraduates. Based on these findings, this study offers targeted recommendations for preventing and mitigating ARSP among female undergraduates: (1) Incorporate an eHL module into the public health curriculum, focusing on developing skills in retrieving, evaluating, and applying health information. The curriculum should include systematic instruction on how to use professional databases such as PubMed and CNKI, as well as academic tools like Google Scholar; analysis of real-world cases, including online health rumors and media sensationalism, to cultivate students' critical thinking about health information; and pay particular emphasis on addressing female college students' specific health information needs to improve their eHL. (2) Regularly organize dedicated seminars at universities to prevent and address MPA among female undergraduates. Specifically, psychological experts will explain the mechanisms of addiction and the dopamine reward system from a neuroscience perspective; present real cases illustrating the negative effects of addiction on academic performance, social life, and health; and impart practical management techniques, such as using screen time tracking apps to monitor daily usage and frequently used applications, along with encouraging daily self-monitoring and adjustments. (3) Foster a campus sports culture that encourages greater participation of female undergraduates in physical activities. This can be achieved by the following methods: offering women-only sports classes (such as yoga and dance) to lower participation barriers; organizing engaging group activities (like fitness challenges and buddy runs) to strengthen social connections; inviting female sports role models to share their experiences; and developing a fitness social app that provides personalized recommendations and community support.

Indeed, this study also has some limitations. (1) This study adopts a cross-sectional approach, which limits the ability to establish causal relationships between variables. Future studies could employ longitudinal approaches to further investigate potential causal relationships. (2) The mediating role of MPA in the relationship between eHL and ARSP among female undergraduates accounts for only 29.7% of the total effect. This suggests that other mediating variables may be involved and warrant further exploration. (2) The samples were undergraduates from specific geographic regions, which may

constrain the generalizability of the findings. Future studies should aim to diversify the samples to enhance the validity of research results.

Conclusion

(1) eHL can significantly and negatively impact the ARSP among female undergraduates, meaning that good eHL can alleviate the ARSP. (2) MPA plays a mediating role between eHL and ARSP, whereby good eHL can reduce MPA behaviour and thus alleviate the ARSP among female undergraduates. (3) PE can significantly moderate the strength of the influences between eHL and ARSP, eHL and MPA, as well as between MPA and ARSP. Regular participation in PE can enhance the negative impact of eHL on ARSP and MPA; at the same time, it can also buffer the positive impact of MPA on ARSP.

Abbreviations

eHL **eHealth literacy**

ARSP **Appearance-related Sociocultural pressure**

MPA **mobile phone addiction**

PE **physical exercise**

Declarations

Competing interests

The authors declare no competing interests.

Author Contributions

Nan Hua was primarily responsible for Conceptualization, Data curation, Investigation, original draft, and Writing - review & editing. Xinchao Gao was mainly involved in original draft and Writing - review & editing for this article.All authors have read andagreed to the published version of the manuscript.

Data Availability Statement

If necessary, the data of this study can be obtained from the corresponding author.

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Figures

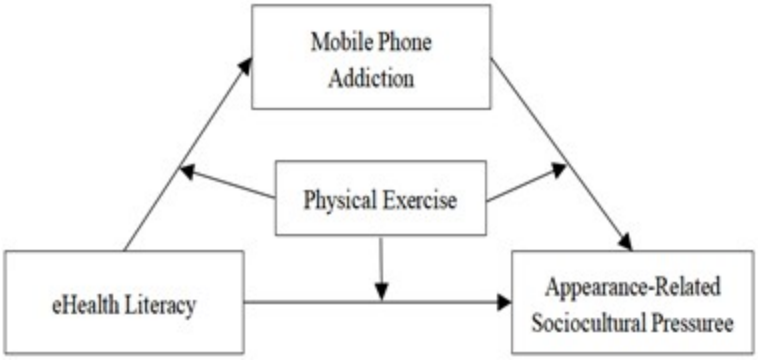


Figure 1

Hypothetical Theory Model

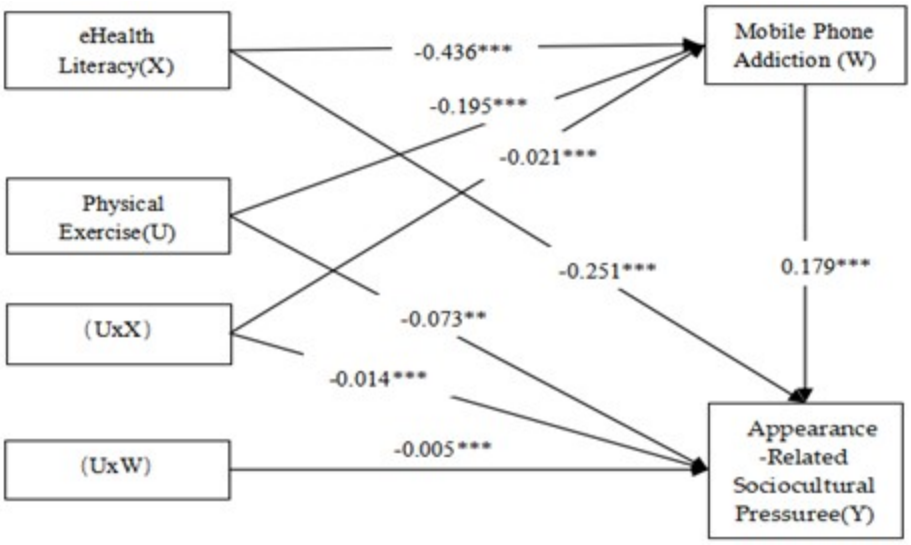


Figure 2

Moderated mediation model

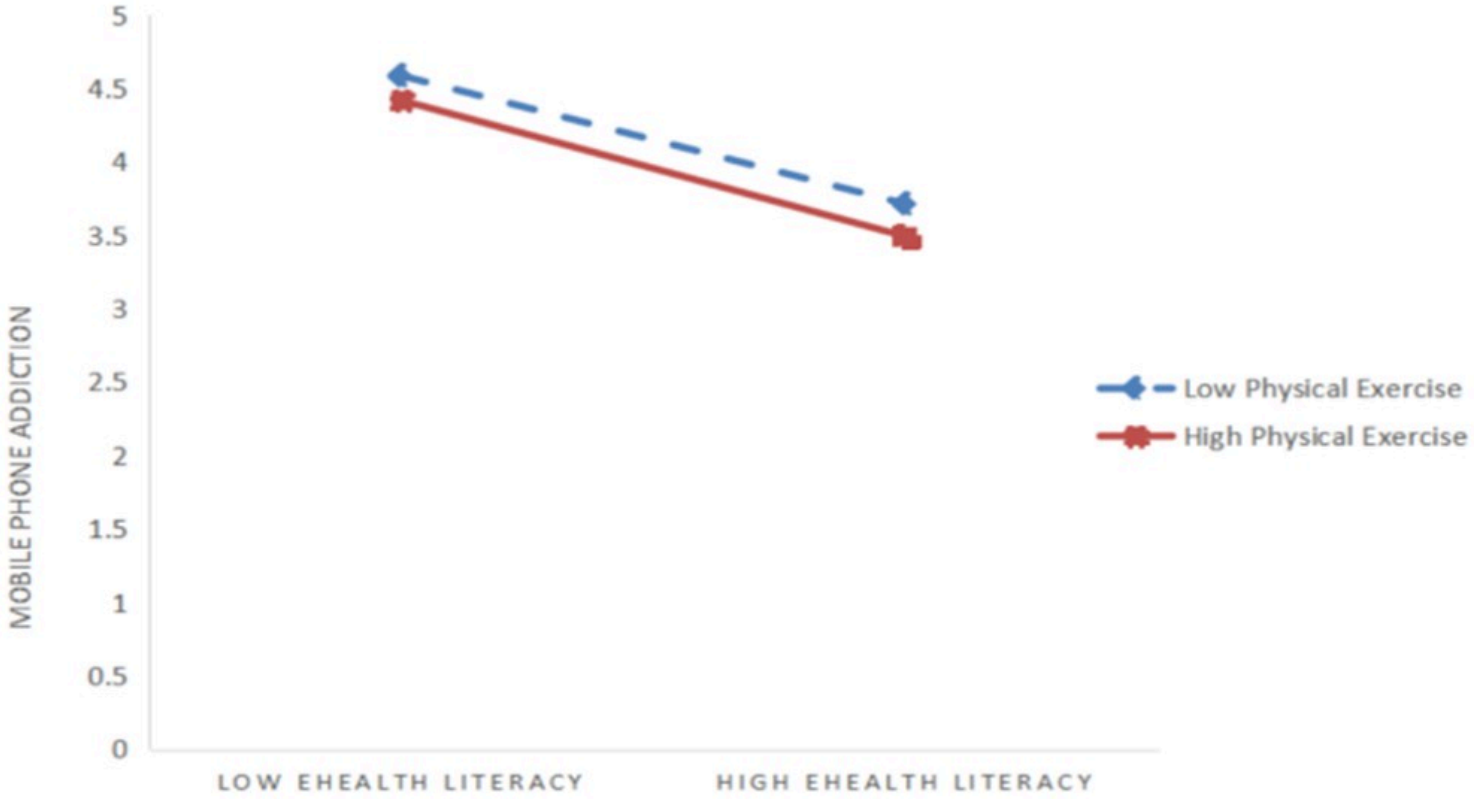


Figure 3

The moderating effect PE in the relationship between eHL and MPA

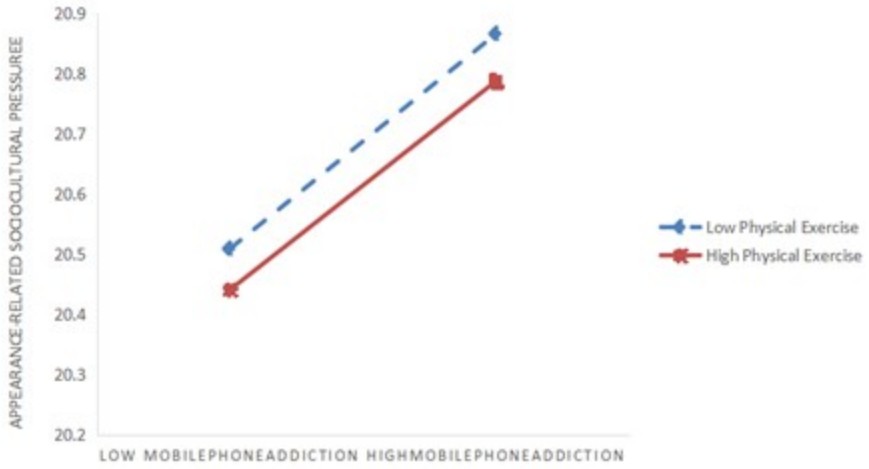


Figure 4

The moderating effect of PE in the relationship between MPA and ARSP

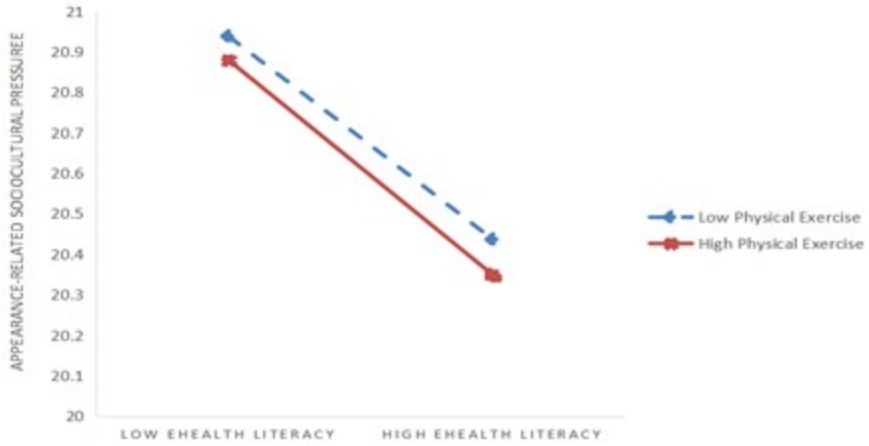


Figure 5

The moderating effect of PE in the relationship between eHL and ARSP