Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

The Association Between Digital Health Literacy and Online Sexual Objectification Among Adolescents: A Serial Mediation Model Involving Physical Activity and Physical Self-Esteem

Peilu Zhao
Henan University
Xinyu Xu
Northeast Normal University
Xiangling Zhang
Shanghai University of Sport
Yuqi Ren
Hong Kong Polytechnic University
Jiaqi Qu
Henan University
Shuhao Zhang
Henan University
Zikun Xiang
166265705290163.com

Jilin University

Article

Keywords: digital health literacy, online sexual objectification, physical activity, physical self-esteem, adolescents

Posted Date: November 12th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11076680/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

The Association Between Digital Health Literacy and Online Sexual Objectification Among Adolescents: A Serial Mediation Model Involving Physical Activity and Physical Self-Esteem

Peilu Zhao[1], Xinyu Xu[2], Xiangling Zhang[3], Yuqi Ren[4], Jiaqi Qu[1], Shuhao Zhang[1], Zikun Xiang[7]*

[1] School of Physical Education, Henan University, Kaifeng 475001, Henan, China；

[2] Northeast Normal University, Changchun 130024, Jilin, China；

[3] School of Physical Education, Shanghai University of Sport, Shanghai 200438, China；

[4] The Hong Kong Polytechnic University, Hung Hom, Kowloon 999077, Hong Kong SAR, China；

[7] Jilin University, Changchun 130012, Jilin, China.

[*]Corresponding author: Zikun Xiang Email: 16626570529@163.com

Background: With the rapid development of digital technologies and the widespread integration of social media into adolescents' lives, this study aimed to examine the association between digital health literacy (DHL) and experiences of online sexual objectification (OSO) among adolescents, along with the mechanisms underlying this association. **Methods:** DHL, OSO, physical activity (PA), and physical self-esteem (PSE) were assessed using the eHealth Literacy Scale (eHEALS), Online Sexual Objectification Experience Scale (OSOES), Physical Activity Rating Scale (PARS-3), and Physical Self-Perception Profile (PSPP) for college students, respectively. Descriptive statistics, Pearson correlation analyses, and hierarchical multiple regression analyses were conducted using SPSS 27.0. Model 6 of PROCESS version 4.1 was used to test individual and serial indirect effects through bootstrapping. **Results:** (1) DHL was significantly negatively associated with OSO among adolescents ($\beta = -0.45$, $p < 0.001$). (2) The indirect effect of DHL on OSO through PA was significant (b = −0.007, 95% CI [−0.009, −0.006]). (3) The indirect effect through PSE was also significant (b = −0.010, 95% CI [−0.012, −0.008]). (4) DHL showed a significant serial indirect association with OSO among adolescents through PA and PSE (b = −0.003, 95% CI [−0.004, −0.003]). **Conclusions:** Higher DHL was associated with fewer experiences of OSO among adolescents, with significant individual and serial indirect effects through PA and PSE. These findings provide empirical support for understanding this association in terms of behavioral engagement and physical self-evaluation.

Keywords: digital health literacy; online sexual objectification; physical activity; physical self-esteem; adolescents

1 Introduction

Digital media are increasingly embedded in adolescent socialization. Their visual communication and quantified feedback mechanisms heighten the visibility of physical appearance and its exposure to evaluation, creating an important risk context for online sexual objectification (OSO) among adolescents (Luo et al., 2026; Nesi et al., 2018). OSO refers to a process in which individuals' bodies or sexualized appearance are evaluated during digital media interactions, reducing them to objects whose worth is judged by visible bodily attributes (Cary et al., 2024; Fredrickson & Roberts, 1997). Adolescence is a critical period of rapid development in physical self-concept and social identity, during which appearance-related online feedback may more readily shape self-evaluation (Choukas-Bradley et al., 2020; Daniels et al., 2020). Existing evidence indicates that self-objectification involves internalizing an external observer's perspective and is associated with lower physical self-esteem (PSE) and greater body surveillance, body shame, and body dissatisfaction (Fredrickson & Roberts, 1997; Moradi & Huang, 2008; Saunders et al., 2024). Longitudinal evidence further suggests that disturbances in body image are prospectively associated with subsequent depression and self-harm (Bornioli et al., 2019; Ferreiro et al., 2012). A national birth cohort study involving 24,569 adolescents found that those who experienced body dissatisfaction in early adolescence had a 78% higher adjusted relative risk of reporting a suicide attempt in late adolescence, with risk increasing progressively as body dissatisfaction intensified (Ørstavik et al., 2026). Strengthening adolescents' ability to identify and manage appearance-focused media risks is therefore an important prerequisite for limiting the internalization of appearance norms and curbing the cascading effects of related risks to physical and mental health.

Social cognitive theory emphasizes that behavioral choices arise from the interplay between individual agency and environmental information (Bandura, 2004). Digital health literacy (DHL), which encompasses the ability to access, evaluate, and apply online health information, is a key cognitive resource supporting health decisions in digital contexts (Ari

as López et al., 2023; Norman and Skinner, 2006; van Kessel et al., 2022). From a medi a literacy perspective, the critical media processing skills supported by DHL may help indi viduals recognize appearance norms and sexualized cues, thereby limiting the influence of appearance-focused and sexualized information on body-related cognitions (McLean et al., 2017; Vandenbosch & van Oosten, 2017). Evidence from related research indicates that dig ital media literacy interventions can reduce body image concerns and thin-ideal internalizati on among adolescents, while higher media literacy may buffer the association between self ie viewing and thin-ideal internalization (Wang et al., 2024; Zuair & Sopory, 2022). A lon gitudinal study found that the association between exposure to sexually explicit online mat erial and perceptions of women as sex objects was weaker among participants who reporte d learning more about pornography in school-based sex education (Vandenbosch & van Oo sten, 2017). However, the association between DHL and experiences of OSO may extend beyond information processing, operating sequentially through engagement in health behavi ors, represented by physical activity (PA), and physical self-evaluation, reflected in PSE (F redrickson & Roberts, 1997; Jiang et al., 2024; Raudsepp et al., 2013; Sonstroem & Morg an, 1989). Supporting evidence indicates that greater participation in sports predicts lower self-objectification one year later (Slater & Tiggemann, 2012). Meanwhile, cross-sectional e vidence shows that lower body esteem is associated with more frequent appearance-related social media activities among adolescent girls, suggesting that negative physical self-evalu ation may be linked to an appearance-focused orientation in online interactions (Kvardova et al., 2026). Together, these findings suggest that cognitive resources for navigating digital environments may reduce susceptibility to objectification risks by promoting behavioral en gagement and the development of a positive physical self-concept.

Drawing on social cognitive theory and objectification theory (see Figure 1), this st udy examines a model linking DHL to OSO among adolescents and tests the serial mediat ing roles of PA and PSE. It aims to elucidate the mechanisms through which cognitive re sources for health translate into body-related psychological adjustment and relate to appear ance-focused digital risks, providing theoretical insights and an empirical basis for promoti ng adolescent digital health and preventing OSO.

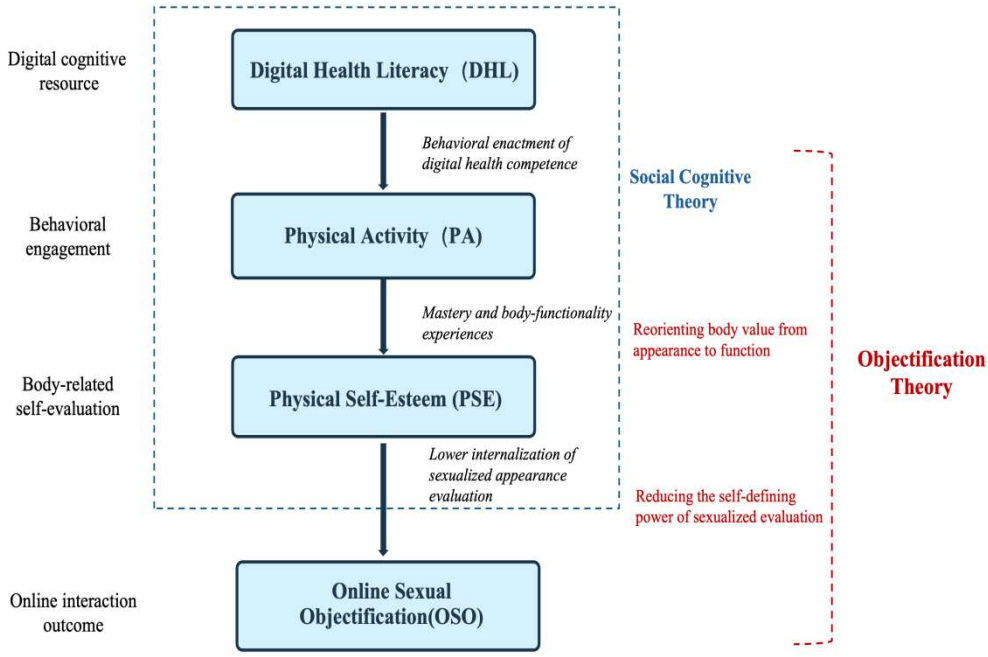


Figure 1. Integrated theoretical framework linking DHL, PA, PSE, and OSO.

1.1 The Association Between DHL and OSO Among Adolescents

In visually oriented digital environments, evaluating health information and navigating appearance-focused interactions constitute two core tasks of adolescent digital adaptation (De Vries et al., 2016; Freeman et al., 2018; Taba et al., 2022). From a critical media processing perspective, the information appraisal skills encompassed by DHL may reduce the internalization of appearance standards and reliance on external evaluation, thereby lowering the likelihood of experiencing OSO (Norman and Skinner, 2006; Vandenbosch & van Oosten, 2017; Zuair & Sopory, 2022). Research involving 246 adolescent girls indicated that higher critical media literacy buffered the adverse associations of thin-ideal internalization and upward appearance comparison with body satisfaction, with this protective role further explored in social media contexts (McLean et al., 2016; McLean et al., 2017). A cross-sectional study found that media literacy significantly moderated the association between selfie viewing and thin-ideal internalization, with a weaker association among adolescents with higher media literacy (Wang et al., 2024). A meta-analysis further showed that school-based media health literacy interventions reduced body image concerns, eating concerns, and

thin-ideal internalization among adolescents, with the largest effect observed for thin-ideal internalization (Zuair & Sopory, 2022). These findings broaden the explanatory framework beyond external media exposure to include modifiable cognitive resources, highlighting their potential upstream role in shaping adolescents' vulnerability to appearance-related risks.

1.2 The Mediating Role of PA in the Association Between DHL and OSO

Embodied action strengthens adolescents' appreciation of what their bodies can do and may attenuate the objectifying influence of sexualized evaluations on digital platforms (Fredrickson & Roberts, 1997; Luo et al., 2026; Slater & Tiggemann, 2012; Sollerhed et al., 2022). From an embodied practice perspective, skill mastery and perceived competence during exercise may reshape the criteria for evaluating the body, grounding its value more firmly in functional experiences than in appearance and thereby reducing the dominance of appearance norms (Abbott & Barber, 2011; O'Hara et al., 2014; Sonstroem & Morgan, 1989). Supporting evidence indicates that interventions focusing on body functionality can increase body appreciation and reduce self-objectification among adult women. A review further highlights the potential value of functionality-based body evaluation for positive body image (Alleva et al., 2015; Alleva & Tylka, 2021). Regarding psychological and behavioral adjustment, a dimension-level network analysis among adolescents found that PA had negative conditional associations with interpersonal stress, impulse control difficulties, and nonsuicidal self-injury (Zhu, Lyu, et al., 2026). Additionally, a study involving 842 adolescent girls found that achievement-oriented sports participation significantly weakened the association between thin-ideal internalization and self-objectification (Jankauskiene & Bacevicience, 2022). Longitudinal research also indicates that sports participation predicts lower subsequent self-objectification (Slater & Tiggemann, 2012), providing indirect support for further investigation of the association between PA and experiences of OSO among adolescents.

The translation of cognitive resources into embodied health practices is embedded in the dynamic interplay between individual agency and supportive environments (Bandura, 2001; Liu et al., 2024; Michie et al., 2011). Across cultural contexts, existing evidence provides preliminary support for a positive association between DHL and PA (Mitsutake et al., 2016; Xu et al., 2026). A cross-sectional study of Chinese university students found that

eHealth literacy was positively associated with moderate-to-vigorous PA, which accounted for a small but significant indirect effect in the association between eHealth literacy and physical literacy (Jiang et al., 2024). A similar association was observed among German eighth- and ninth-grade students, with low and moderate DHL associated with a greater likelihood of insufficient PA (Dadaczynski et al., 2022). A cross-sectional survey of 19,231 residents aged 16 years and older in Denmark's Zealand region found that, after adjustment for sociodemographic factors and body mass index, higher DHL was associated with a greater likelihood of engaging in more than 30 minutes of moderate-to-vigorous PA per week and meeting the World Health Organization's minimum PA recommendations for adults (Zangger et al., 2024). Together, these findings suggest that embodied action may serve as an active mechanism linking digital competencies to positive physical self-development.

1.3 The Mediating Role of PSE in the Association Between DHL and OSO

PSE encompasses individuals' multidimensional evaluations of their physical appearance, physical competence, and overall physical worth (Fox & Corbin, 1989; Franzoi & Shields, 1984; Mendelson et al., 2001). As an important component of positive body image, higher PSE may serve as a psychological resource that helps adolescents navigate appearance-focused digital environments (Kvardova et al., 2026; Steinsbekk et al., 2021; Yang et al., 2020). Research among adolescents found that body satisfaction was negatively associated with coercive sextortion and online grooming, whereas sending erotic and pornographic messages was positively associated with online grooming (Tamarit et al., 2021). A cross-sectional study among adults showed that PSE was negatively associated with motivations to enhance body image, which were positively associated with posting sexualized content of oneself online (Califano et al., 2022). Cross-sectional research among adolescent girls further indicated that body image concerns may increase vulnerability to online sexual victimization through greater tendencies to expand online contacts indiscriminately and establish online relationships with strangers (Longobardi et al., 2021). Through related mechanisms involving sexualized self-presentation and risky online interactions, these studies provide indirect empirical support for the potential protective role of PSE against OSO.

Within an increasingly complex online health information environment, the ability to access, evaluate, and apply digital health information may constitute an important cognitive resource for maintaining positive physical self-evaluation (Mahdifar et al., 2021; Norman and Skinner, 2006). In particular, critical appraisal of health information may limit the biased internalization of appearance norms and reliance on external evaluation, helping individuals develop a stable sense of physical worth (McLean et al., 2013, 2016; Paxton et al., 2022; Tamplin et al., 2018). Quasi-experimental research indicates that social media literacy training can improve weight-related body esteem among adolescent girls in the short term (McLean et al., 2017). Additionally, a cross-sectional study among university students found a weak positive correlation between eHealth dietary literacy and body appreciation (Adiyan & Lule, 2026). Thus, the value of DHL may extend beyond supporting health-related behavioral decisions: by strengthening individuals' sense of physical worth, it may translate cognitive advantages in health information processing into psychological resources that support positive body-related adjustment among adolescents.

1.4 The Serial Mediating Roles of PA and PSE in the Association Between DHL and OSO

The exercise and self-esteem model proposes that mastery experiences accumulated through exercise strengthen positive perceptions of specific physical abilities. These perceptions extend upward through the hierarchy of physical self-perceptions, reinforcing individuals' sense of overall physical worth (Fox & Corbin, 1989; Gothe et al., 2022; Haugen et al., 2011; Sonstroem & Morgan, 1989). Existing evidence, derived predominantly from female samples, supports a positive association between PA and PSE (Raudsepp et al., 2013). A six-month cluster randomized controlled trial found significant improvements in perceived physical condition and physical self-worth among insufficiently active female high school students (Kahlin et al., 2016). Similarly, a 14-week exercise intervention improved physical self-worth among adolescents with obesity despite no significant change in body mass index (Daley et al., 2006). A meta-analysis of nine randomized controlled trials further demonstrated a small positive effect of exercise on overall PSE among females (Zhang et al., 2024). These findings suggest that PA can strengthen adolescents' positive evaluations of thei

r bodily functionality and physical competence, offering a modifiable behavioral pathway f or developing a stable physical self-identity.

Cognitive resources for health in digital environments may translate into advantages in adapting to online interactions through a sequential pathway involving behavioral engagem ent and the integration of a sense of physical worth (Kim et al., 2023; Longobardi et al., 2021; Melby et al., 2023; Ojala et al., 2021; Paquette et al., 2022). From an embodied a gency perspective, functional experiences may strengthen bodily agency, while positive phy sical self-evaluation may reduce reliance on appearance-based validation, jointly lowering s usceptibility to OSO (Adams et al., 2017; Bell et al., 2018; Mahlo & Tiggemann, 2016). A cross-sectional study of 842 adolescent girls found that achievement-oriented sports parti cipation significantly weakened the association between thin-ideal internalization and self-ob jectification (Jankauskiene & Baceviciene, 2022). Meanwhile, cross-sectional data from 190 adolescents indicated that both body-esteem attribution and objectified body consciousness significantly predicted sexting motivations related to sexual purposes (Bianchi et al., 201 7). The adaptive advantages of health literacy are reflected in more effective engagement i n health behaviors (Fleary et al., 2018; Hnidková et al., 2024; Zhu, Du, et al., 2026) and more positive physical self-evaluation (Kurz et al., 2022; Mahdifar et al., 2021). Thus, by promoting PA and reinforcing positive physical self-evaluation, DHL may translate cogniti ve advantages in health information processing into upstream protection against adolescents' susceptibility to OSO.

1.5 Research Gaps

Building on the literature reviewed above, this study aims to systematically examine the association between DHL and OSO among adolescents and test the mediating roles of PA and PSE. Three gaps remain in the existing literature. First, few studies have systematically examined the association between DHL and OSO among adolescents, despite the potential role of DHL as a cognitive resource supporting critical information appraisal and health-related decision-making. Second, previous research has predominantly focused on female or university student samples, emphasizing self-objectification and its psychological consequences while paying limited attention to upstream protective mechanisms against adolescent OSO. The protective value and

intervention potential of PA and PSE have yet to be assessed from an integrated perspective encompassing health behavior regulation and physical self-concept development. Third, existing studies have largely examined associations among selected variables, without a unified theoretical framework integrating digital cognitive resources, health behavior practices, and physical self-evaluation. This fragmentation limits understanding of the behavioral and psychological processes underlying the association between DHL and OSO among adolescents. Based on the preceding theoretical analysis and review of empirical evidence, this study proposes the following hypotheses, as illustrated in Figure 2:

H_1: DHL is negatively associated with OSO among adolescents.

H_2: PA mediates the association between DHL and OSO among adolescents.

H_3: PSE mediates the association between DHL and OSO among adolescents.

H_4: PA and PSE sequentially mediate the association between DHL and OSO among adolescents.

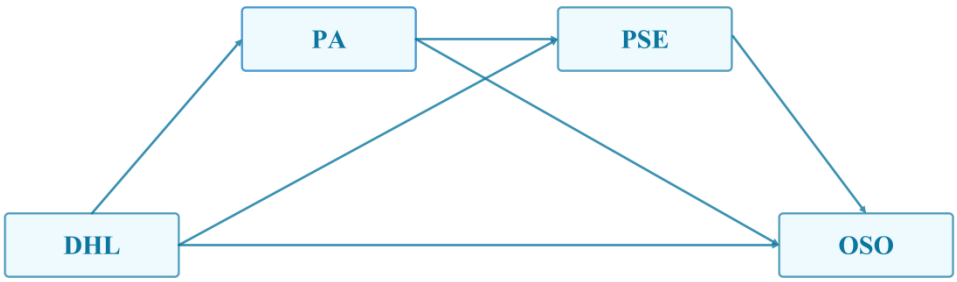


Figure 2. Serial mediation model of PA and PSE in the association between DHL and OSO.

Note: Digital health literacy =DHL; Online Sexual Objectification = OSO; Physical activity = PA; Physical Self-Esteem = PSE.

2. Methods

2.1 Participants

This cross-sectional study recruited participants from four secondary schools in urban areas of Henan Province, China. Researchers screened 2,698 students for eligibility based on their self-reported health status (Figure 3). Of these, 79 students who reported health conditions affecting daily activities were excluded, leaving 2,619 eligible students. Questionnaires were

distributed to all eligible students, and 2,409 valid responses were included in the final analysis, yielding a valid response rate of 92.0%. The detailed screening process is presented in Figure 3.

To assess the adequacy of the achieved sample size, a Monte Carlo sensitivity analysis was conducted for the hypothesized serial mediation model. With a sample size of N = 2,409 and a significance level of $\alpha = 0.05$, the study had 95% statistical power to detect a standardized serial indirect effect as small as 0.0017, supporting the adequacy of the sample size under the specified model assumptions. Among the 2,409 respondents with valid responses, 1,068 (44.3%) were boys. The mean age was 15.05 ± 1.72 years. Detailed demographic characteristics are presented in Table 1.

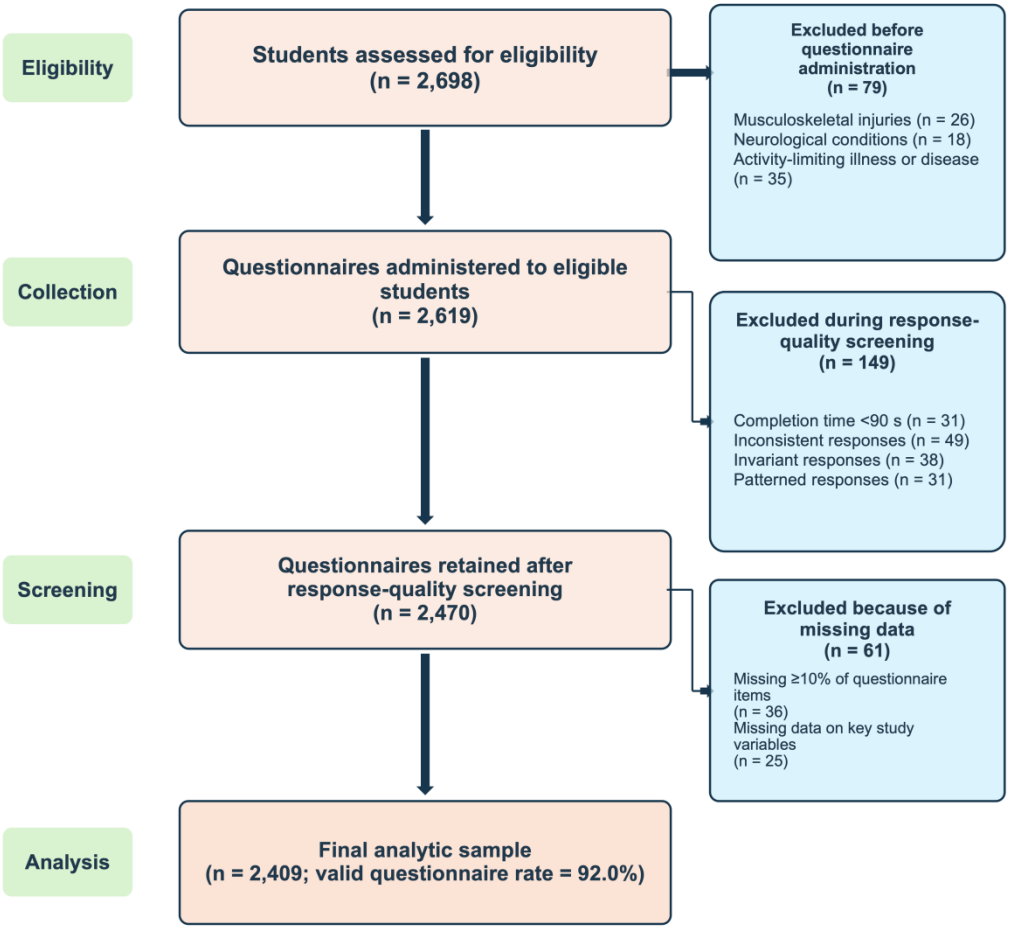


Figure 3. Flowchart of the study sample selection process.

To ensure that the sample aligned with the study objectives and to maintain data quality, explicit inclusion and exclusion criteria were established a priori based on the research objectives and measurement requirements. The inclusion criteria were as follows: (1) current enrollment as a

full-time junior or senior secondary school student; (2) intact cognitive functioning and reading comprehension sufficient to complete the self-administered questionnaire independently and accurately; and (3) voluntary participation, with written informed consent from a parent or legal guardian and written assent from the adolescent. The exclusion criteria were as follows: (1) recent physical injury or medical advice against exercise; (2) a confirmed diagnosis of another neurodevelopmental disorder or a neurological disease; and (3) an acute or chronic illness.

Table 1. Distribution of basic information on adolescents (N = 2409).

Demographic variables		Number	Proportion (%)
Age	15.05±1.72	2409	100%
Sex	Male	1068	44.3%
	Female	1341	55.7%
Grade level	Middle school	1166	48.4%
	High school	1243	51.6%
Place of birth	Rural	1007	41.8%
	Urban	1402	58.2%
Only child (yes/no)	Yes	649	26.9%
	No	1760	73.1%
Boarding student (yes/no)	Yes	1749	72.6%
	No	660	27.4%

2.2 Study Procedure

This study was conducted in Henan Province, China, between March and June 2026. Schools were selected through purposive sampling, and eligible students within participating schools were recruited through convenience sampling. The study was approved by the Biomedical Research Ethics Subcommittee of Henan University (approval number: HUSOM2026-877), and permission was obtained from the local education authorities and participating schools. All study procedures were performed in accordance with the Declaration of Helsinki and relevant institutional and national guidelines and regulations. Before data collection, written informed consent was obtained from the parents or legal guardians of all participants. Participants themselves also provided written assent after receiving comprehensive information about the study.

Research assistants who had received standardized training administered the questionnaires in classroom settings using standardized procedures. Before the survey, participants were informed of the study purpose, the voluntary nature of participation, anonymity, data confidentiality measures, and their right to withdraw at any time. Participants independently completed and submitted the questionnaires via an online survey platform. Researchers

subsequently checked the questionnaires for completeness and promptly clarified any unintentional omissions with participants.

2.3 Measures

2.3.1 Digital Health Literacy

DHL was assessed using the Chinese version of the eight-item eHealth Literacy Scale (eHEALS), originally developed by Norman and Skinner (2006) and adapted into Chinese by Guo et al. (2013). The scale assesses respondents' perceived ability to find, evaluate, and use online health information (Zhao et al., 2026). Items are rated on a five-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). Scores are summed to yield a total score ranging from 8 to 40, with higher scores indicating greater perceived eHealth literacy. Cronbach's α in the present sample was 0.91.

2.3.2 Online Sexual Objectification

Experiences of OSO were assessed using the Online Sexual Objectification Experience Scale (OSOES) employed by Luo (2017). The scale comprises six items assessing how frequently individuals experience attention, comments, or evaluations from others regarding their appearance and bodily features in online settings. All items are rated on a five-point Likert scale ranging from 1 to 5. Higher scores indicate more frequent experiences of OSO. Previous studies have demonstrated good internal consistency, and the scale has been used in different samples of Chinese youth (Du et al., 2023; Gai et al., 2026). In the present study, Cronbach's α was 0.85, indicating good internal consistency.

2.3.3 Physical Activity

PA was assessed using the Physical Activity Rating Scale-3 (PARS-3), revised by Liang (1994). The scale comprises three items assessing exercise intensity, duration, and frequency. Each item is scored from 1 to 5. The total PA score is calculated as intensity × (duration − 1) × frequency, yielding a score ranging from 0 to 100, with higher scores indicating greater physical activity (Zhang et al., 2025). In the present study, Cronbach's α was 0.78.

2.3.4 Physical Self-Esteem

PSE was assessed using the college-student version of the Physical Self-Perception Profile (PSPP), revised by Xu and Yao (2001). The scale comprises 30 items, including a global physical self-worth scale and four subscales assessing sport competence, physical condition, body attractiveness, and physical strength. Sixteen items are reverse-scored. All items are rated on a four-point Likert scale ranging from 1 (strongly disagree) to 4 (strongly agree), with higher scores indicating higher PSE. Previous research has demonstrated good internal consistency in Chinese adolescent samples (Peng et al., 2025). In the present study, Cronbach's α was 0.912, indicating good internal consistency.

2.4 Data Analysis

Statistical analyses were conducted using IBM SPSS Statistics 27.0. All statistical tests were two-sided, with the significance level set at $\alpha = 0.05$. First, the data were screened and checked for quality, and Harman's single-factor test was used to assess common method bias. Descriptive statistics were then calculated for DHL, OSO, PA, and PSE. Continuous variables were summarized as means and standard deviations ($M \pm SD$), and Pearson correlation analyses were performed to examine bivariate associations among the main variables. Hierarchical multiple linear regression models were subsequently fitted to examine the independent predictive contributions of the core variables to the outcome, controlling for relevant demographic variables. Before regression analysis, multicollinearity was assessed using indicators including the variance inflation factor (VIF). Finally, Model 6 of Hayes' PROCESS macro was used to test serial mediation. Indirect effects and their 95% confidence intervals were estimated using 5,000 bootstrap resamples. An indirect effect was considered statistically significant when its bootstrap 95% confidence interval did not include zero.

3. Results

3.1 Common Method Bias Test

Because all variables were assessed using self-report questionnaires, Harman's single-factor test was conducted to evaluate the potential influence of common method bias. The results showed that principal component analysis extracted 13 factors with eigenvalues greater than 1, which

collectively accounted for 87.36% of the total variance. The first unrotated factor explained 27.18% of the variance, well below the recommended threshold of 40%. These findings indicate that there was no serious common method bias in the data.

3.2 Descriptive Statistics and Correlation Analysis

Table 2 presents the means, standard deviations, and correlations among DHL, OSO, PA, and PSE. The mean scores (standard deviations) were 24.31 (5.34) for DHL, 12.78 (3.36) for OSO, 29.47 (21.17) for PA, and 84.13 (16.80) for PSE. DHL was significantly negatively correlated with OSO ($r = -0.448$, $p < 0.001$) and positively correlated with PA ($r = 0.347$, $p < 0.001$) and PSE ($r = 0.415$, $p < 0.001$). PA was significantly negatively correlated with OSO ($r = -0.412$, $p < 0.001$) and positively correlated with PSE ($r = 0.411$, $p < 0.001$). Additionally, PSE was significantly negatively correlated with OSO ($r = -0.494$, $p < 0.001$).

346 **Table 2. Means, standard deviations, and correlations among all variables (*N* = 2409).**

Variable	*M*	*SD*	1	2	3	4
1. DHL	24.31	5.34	1	-0.448*	0.347*	0.415*
2.OSO	12.78	3.36	-0.448*	1	-0.412*	-0.494*
3. PA	29.47	21.17	0.347*	-0.412*	1	0.411*
4. PSE	84.13	16.80	0.415*	-0.494*	0.411*	1

347 **Note: Digital health literacy =DHL; Online Sexual Objectification = OSO; Physical activity = PA; Physical**
348 **Self-Esteem = PSE.***p < 0.05; **p < 0.01; ***p < 0.001.

349 **3.3 Regression Analysis**

350 Hierarchical multiple regression analyses were conducted to examine whether DHL, PA, and
351 PSE predicted OSO, with the results presented in Table 3. Before the analyses, multicollinearity
352 diagnostics were performed for all predictors. VIF values ranged from 1.002 to 3.062, well below
353 the threshold of 10, indicating no serious multicollinearity concerns for the subsequent regression
354 and mediation analyses.

355 In Model 1, demographic variables, including sex, age, grade, birthplace, only-child status,
356 and boarding status, were entered as covariates. DHL was subsequently added in Model 2 and
357 significantly negatively predicted OSO ($\beta = -0.45$, $p < 0.001$), supporting H1. Model 3 further
358 showed that PA significantly negatively predicted OSO ($\beta = -0.29$, $p < 0.001$). After PSE was
359 added in Model 4, it also emerged as a significant negative predictor of OSO ($\beta = -0.31$, $p <$
360 0.001).

361 Additionally, Model 5 showed that DHL significantly positively predicted PA ($\beta = 0.35$, $p <$
362 0.001). Finally, Model 6 indicated that PA was a significant positive predictor of PSE ($\beta = 0.30$, p
363 < 0.001). Overall, the hierarchical regression analyses revealed significant associations among
364 DHL, PA, and PSE, each of which was also significantly associated with OSO.

365

366

Table 3. Standardized regression coefficients and model-fit statistics for the regression models

Variable		Dependent variable: OSO								Dependent variable: PA		Dependent variable: PSE	
		Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
		β	*t*	β	*t*	β	*t*	β	*t*	β	*t*	β	*t*
Control variables	Sex	0.08	3.87*	0.06	3.55*	0.06	3.29	0.07	3.99*	-0.03	-1.37	0.03	1.58
	Age	-0.04	-1.10	-0.02	-0.48	-0.03	-1.00	-0.03	-0.93	-0.05	-1.54	0.01	0.36
	Grade level	0.05	1.38	0.05	1.69	0.06	2.06*	0.06	1.94	0.03	0.92	-0.02	-0.70
	Place of birth	0.01	0.56	0.00	0.15	0.00	0.28	-0.00	-0.28	0.01	0.39	-0.03	-1.73
	only child or not	-0.00	-0.16	-0.00	-0.08	-0.01	-0.52	-0.02	-1.28	-0.03	-1.37	-0.04	-2.21*
	Boarding or not	-0.00	-0.01	0.01	0.70	0.02	1.01	0.02	0.97	0.02	0.84	-0.01	-0.29
Independent variable	DHL	-	-	-0.45	-24.58*	-0.35	-18.75*	-0.25	-13.52*	0.35	18.14*	0.31	16.48*
Mediating variables	PA	-	-	-	-	-0.29	-15.71*	-0.20	-10.60*	-	-	0.30	16.19*
	PSE	-	-	-	-	-	-	-0.31	-16.32*	-	-	-	-
Model fit	*R*	0.08		0.45		0.53		0.59		0.35		0.51	
	R^2	0.01		0.21		0.28		0.35		0.12		0.26	
	Adjusted R^2	0.00		0.20		0.28		0.35		0.12		0.25	
	F	2.85		89.34*		117.03*		145.14*		48.23*		103.70*	

Note: Digital health literacy =DHL; Online Sexual Objectification = OSO; Physical activity = PA; Physical Self-Esteem = PSE. *p < 0.05; **p < 0.01; ***p < 0.001.

3.4 Mediation Analysis

The standardized path coefficients of the serial mediation model are presented in Figure 4, and the mediation analysis results are reported in Table 4. The total effect of DHL on OSO among adolescents was statistically significant (b = −0.047, bootstrap 95% CI [−0.051, −0.044]). After PA and PSE were included in the model, the direct effect of DHL on OSO remained statistically significant (b = −0.026, bootstrap 95% CI [−0.030, −0.023]), accounting for 55.9% of the total effect. The total indirect effect through PA and PSE was also statistically significant (b = −0.021, bootstrap 95% CI [−0.023, −0.019]), accounting for 44.1% of the total effect.

Table 4. Indirect Effects and Effect Sizes Path	Effect	*SE*	Bootstrap 95% CI		Percentage of total effect
			Lower	Upper	
Total effect	-0.047	0.002	-0.051	-0.044	-
Direct effect	-0.026	0.002	-0.030	-0.023	55.9%
Total indirect effects	-0.021	0.001	-0.023	-0.019	44.1%
Ind1: DHL->PA->OSO	-0.007	0.001	-0.009	-0.006	15.2%
Ind2: DHL->PSE->OSO	-0.010	0.001	-0.012	-0.008	21.5%
Ind3: DHL->PA->PSE->OSO	-0.003	0.001	-0.004	-0.003	7.3%

Specifically, the analysis of Ind1 indicated that PA significantly mediated the association between DHL and OSO, with an indirect effect of −0.007 (bootstrap 95% CI [−0.009, −0.006]), accounting for 15.2% of the total effect and supporting H2. The results for Ind2 showed that PSE also significantly mediated the association between DHL and OSO, with an indirect effect of −0.010 (bootstrap 95% CI [−0.012, −0.008]), accounting for 21.5% of the total effect and supporting H3. Additionally, DHL was indirectly associated with OSO through the serial pathway PA → PSE. The serial indirect effect was −0.003 (bootstrap 95% CI [−0.004, −0.003]), accounting for 7.3% of the total effect. The confidence interval excluded zero, supporting H4.

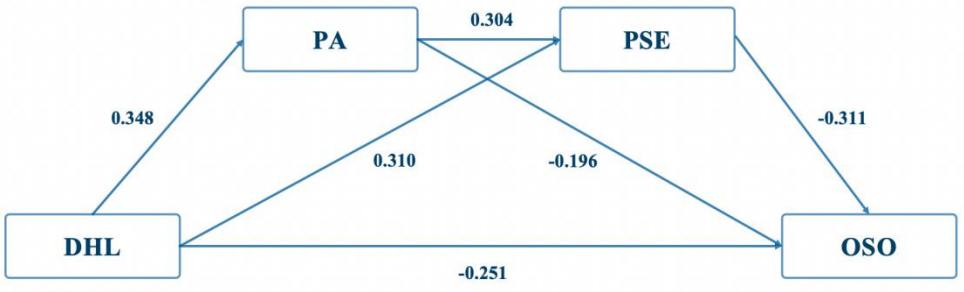


Figure 4. Serial mediation model with standardized path coefficients

Note. Values shown on arrows are standardized path coefficients. DHL, PA, PSE, and OSO follow the study abbreviations.

4. Discussion

4.1 The Association Between DHL and OSO

This study found a significant negative association between DHL and OSO among adolescents, indicating that adolescents with higher DHL generally reported lower OSO, supporting H1. This finding aligns closely with social cognitive theory, which emphasizes how individual cognitive resources shape the recognition, appraisal, and response to environmental cues (Bandura, 2001). Related experimental studies provide converging evidence (Reichert et al., 2007) found that, following media literacy training addressing the sexual objectification of women in advertising, participants were better able to recognize objectifying portrayals and demonstrated more critical cognitive, attitudinal, and behavioral responses to these advertisements. In a randomized controlled trial, (Scull et al., 2022) found that online media literacy-based sexual health education improved adolescents' ability to deconstruct media messages, reduced perceptions of media realism, and corrected overestimates of the prevalence of risky sexual behaviors among adolescents.

Previous research has primarily examined manifestations of OSO and their associations with psychological outcomes such as self-objectification, body surveillance, and body shame (Cary et al., 2024), with comparatively limited attention to upstream protective factors (Ward et al., 2023). By identifying a significant negative association between DHL and OSO among adolescents, this study extends the focus from risk manifestations and their consequences to the potential protective role of modifiable digital cognitive resources. In practical terms, the findings suggest that DHL should be incorporated into adolescent online risk prevention efforts. School-based education could strengthen the recognition of objectifying cues and awareness of boundaries in sexualized interactions, while family support and platform governance could provide external safeguards. Together, these approaches offer a multilevel foundation for strengthening adolescents' capacity to respond to OSO and reducing related risks (Calvete et al., 2022; Quayle, 2020; Scull et al., 2022).

4.2 The Mediating Role of PA in the Association Between DHL and OSO

PA significantly mediated the association between DHL and OSO, supporting H2. Higher PA was associated with lower OSO. From an embodied perspective, skill mastery, functional experiences, and autonomous control during exercise may be linked to a stronger sense of bodily agency and less reliance on evaluations of appearance and sexual attractiveness among adolescents (Cox et al., 2016; Daubenmier, 2005; Piran et al., 2020). Previous research provides support through both behavioral engagement and shifts in body evaluation: longitudinal associations involving adolescent sports participation and intervention effects of functionality-focused training among adult women both point to lower self-objectification (Alleva et al., 2015; Slater & Tiggemann, 2012).

The present study further identified an association between PA and OSO in online interpersonal interactions, suggesting a connection across contexts between offline embodied practices and experiences of sexualized evaluation online. Related research has also incorporated PA into symptom networks of adolescent internet addiction, internalizing problems, and nonsuicidal self-injury, identifying negative associations with related symptoms. These findings provide additional evidence linking exercise participation to internet-related psychological and behavioral problems (Zhu, Du, et al., 2025). Thus, this study extends the potential psychosocial relevance of PA from body image to risks associated with adolescent digital socialization and provides preliminary support for incorporating functionality- and competence-oriented exercise practices into OSO prevention.

4.3 The Mediating Role of PSE in the Association Between DHL and OSO

The indirect effect linking DHL to OSO through PSE was significant, supporting H3. Higher PSE was associated with lower OSO, possibly because a stable sense of physical worth reduces adolescents' reliance on standards of appearance and sexual attractiveness. This association may therefore reflect individual differences in the cognitive and behavioral processes involved in recognizing, interpreting, and responding to sexualized evaluations, rather than indicating that PSE can alter objectifying experiences themselves. Existing evidence has primarily followed two lines of inquiry: the adverse consequences of objectification and positive body image. These

address, respectively, the association between objectifying experiences and negative body-related cognitions (Moradi & Huang, 2008), and the role of body appreciation and functionality-oriented evaluation in reducing the influence of appearance norms (Alleva et al., 2015; Andrew et al., 2015; Linardon et al., 2023). Whereas previous research has largely treated body evaluation as a psychological outcome of objectifying experiences, this study examines PSE as a potential basis for understanding individual differences in adolescent OSO. This perspective extends the focus of objectification theory from how external sexualized evaluations shape negative body-related cognitions to how individuals' existing evaluations of physical worth relate to their online interaction experiences. It thereby introduces an individual-differences perspective into traditional models of risk and its consequences, offering an explanatory framework that considers both the external evaluative environment and differences in perceived physical worth.

This study also found a significant positive association between DHL and PSE, suggesting that stronger critical processing skills for digital health information may be associated with less reliance on appearance norms and a greater emphasis on health and bodily functionality in self-evaluation. Related research has examined health literacy and weight-related self-perceptions, alongside the roles of media pressure, appearance comparison, social evaluation, appearance-ideal internalization, and body satisfaction in shaping physical self-perceptions (Boberová & Husárová, 2021; Ji et al., 2023; Rodgers et al., 2015). The theoretical contribution lies in extending DHL research beyond information processing and health-related decision-making to physical self-concept, while broadening PSE research beyond external sociocultural pressures to consider digital information environments alongside individual cognitive resources. This perspective suggests that adolescents' physical self-evaluations may involve both responses to appearance norms and judgments of physical worth formed when selecting, weighing, and integrating health information. The positive association between DHL and PSE thus provides empirical support for understanding individual differences in adolescent PSE through digital health information competencies, although the specific cognitive processes require further investigation.

4.4 The Serial Mediating Roles of PA and PSE in the Association Between DHL and OSO

The serial indirect effect linking DHL to OSO through PA and PSE was significant, supporting H4. Adolescence involves rapid physical development, during which

appearance-related social evaluations increasingly shape physical self-perceptions (Voelker et al., 2015). Longitudinal research among adolescents has identified associations between PA and indicators such as perceived competence and physical self-worth, providing evidence for the relationship between exercise participation and body evaluation (Inchley et al., 2011). The developmental theory of embodiment offers a theoretical basis for considering the significance of experiences of bodily functionality and agency (Piran et al., 2020). Related studies have examined the association between PA and PSE in contexts ranging from everyday exercise participation to exercise interventions (Ojala et al., 2021; Zhang et al., 2024) Evidence from a related study of autistic adolescents identified a serial indirect association between PA and internalizing problems through sports friendship quality and social-emotional competence (Zhu, Li, et al., 2025).

The present study incorporated the relationship between PA and PSE into an analytical framework linking DHL to experiences of OSO among adolescents, identifying a significant serial indirect association through behavioral engagement and physical self-evaluation. Its theoretical contribution lies in integrating health behavior and physical self-evaluation into an explanatory framework for adolescent OSO, providing empirical support for understanding the connections among digital health competencies, offline exercise participation, and online sexualized interactions. This finding also offers a basis for examining individual differences in OSO by combining the emphasis on individual agency in social cognitive theory with the focus on bodily experiences in objectification theory (Bandura, 2001; Fredrickson & Roberts, 1997). These sequential relationships represent statistical associations within the hypothesized model; their temporal ordering and specific mechanisms require further examination through longitudinal or intervention studies.

5. Conclusions

This study found that higher DHL was associated with fewer experiences of OSO among adolescents. Both the individual and serial indirect effects through PA and PSE were significant, and the direct association remained significant after both mediators were included. These findings suggest that the connection between digital health competencies and online interaction experiences involves both everyday exercise participation and physical self-evaluation, providing behavioral and psychological evidence for understanding individual differences in adolescent

OSO. The findings also suggest directions for prevention research that jointly considers health information competencies, exercise participation, and PSE. However, the temporal ordering, causal mechanisms, and intervention effects require further investigation through longitudinal and experimental studies.

6. Limitations and Future Directions

Several limitations should be acknowledged. First, the model was constructed using total scale scores, without distinguishing between the subdimensions of DHL and PSE, the activity components of PA, or specific manifestations of OSO. Treating these constructs as aggregate measures may obscure dimension-specific associations. Future research could use subscale- or item-level analyses to identify the roles of different components. Second, the cross-sectional design limits inferences about causality and temporal ordering. Although the theoretical framework and statistical findings support the proposed serial mediation model, longitudinal or experimental intervention designs are needed to examine the long-term associations and directionality of the pathways among DHL, PA, PSE, and OSO. Third, all data were self-reported and may be subject to social desirability and recall biases. Future studies could incorporate digital health information appraisal tasks, wearable device recordings, and ecological momentary assessment to improve measurement objectivity and the robustness of the findings. Finally, convenience sampling through an online survey platform, together with the recruitment of participants primarily from urban schools in a specific region of China, may introduce selection bias and limit the generalizability of the findings. Future research could employ stratified multistage probability sampling with broader coverage across regions, urban and rural settings, and cultural contexts to improve sample representativeness and external validity.

Acknowledgments

The authors thank all participants who took part in this study.

Data Availability Statement

The original contributions presented in this study are included in the article and its supplementary material. Further inquiries can be directed to the corresponding author.

Funding

The authors received no financial support for the research.

Author Contributions

PL-Z led the data analysis and manuscript preparation and contributed to manuscript review and editing, methodology, investigation, and project administration. ZK-X provided overall supervision and contributed to manuscript review and editing, software development, and data visualization. XY-X and YQ-R curated the data. JQ-Q and XL-Z contributed to study design. SH-Z assisted with data analysis. All authors read and approved the final version of the manuscript.

Ethics declarations

This study was approved by the Biomedical Research Ethics Subcommittee of Henan University (approval number: HUSOM2026-877). All methods were performed in accordance with the Declaration of Helsinki and relevant guidelines, regulations, and institutional requirements. Written informed consent was obtained from all adolescent participants and their parents or legal guardians.

Competing interests

The authors declare no competing interests.

References:

Abbott, B. D., & Barber, B. L. (2011). Differences in functional and aesthetic body image between sedentary girls and girls involved in sports and physical activity: Does sport type make a difference? *Psychology of Sport and Exercise, 12*(3), 333–342. https://doi.org/10.1016/j.psychsport.2010.10.005

Adams, K. E., Tyler, J. M., Calogero, R., & Lee, J. (2017). Exploring the relationship between appearance-contingent self-worth and self-esteem: The roles of self-objectification and appearance anxiety. *Body Image, 23*, 176–182. https://doi.org/10.1016/j.bodyim.2017.10.004

Adiyan, N. N., & Lule, N. O. (2026). Attitudes toward artificial intelligence tools in university students: Associations with body appreciation and e-healthy diet literacy—Implications for digital health education. *BMC Medical Education, 26*(1), Article 1162. https://doi.org/10.1186/s12909-026-09506-y

Alleva, J. M., Martijn, C., Van Breukelen, G. J. P., Jansen, A., & Karos, K. (2015). Expand Your Horizon: A programme that improves body image and reduces self-objectification by training women to focus on body functionality. *Body Image, 15*, 81–89. https://doi.org/10.1016/j.bodyim.2015.07.001

Alleva, J. M., & Tylka, T. L. (2021). Body functionality: A review of the literature. *Body Image, 36*, 149–171. https://doi.org/10.1016/j.bodyim.2020.11.006

Andrew, R., Tiggemann, M., & Clark, L. (2015). The protective role of body appreciation against media-induced body dissatisfaction. *Body Image, 15*, 98–104. https://doi.org/10.1016/j.bodyim.2015.07.005

Arias López, M. del P., Ong, B. A., Borrat Frigola, X., Fernández, A. L., Hicklent, R. S., Obeles, A. J. T., Rocimo, A. M., & Celi, L. A. (2023). Digital literacy as a new determinant of health: A scoping review. *PLOS Digital Health, 2*(10), Article e0000279. https://doi.org/10.1371/journal.pdig.0000279

Bandura, A. (2001). Social cognitive theory: An agentic perspective. *Annual Review of Psychology, 52*, 1–26. https://doi.org/10.1146/annurev.psych.52.1.1

Bandura, A. (2004). Health promotion by social cognitive means. *Health Education & Behavior, 31*(2), 143–164. https://doi.org/10.1177/1090198104263660

Bell, B. T., Cassarly, J. A., & Dunbar, L. (2018). Selfie-objectification: Self-objectification and positive feedback ("likes") are associated with frequency of posting sexually objectifying self-images on social media. *Body Image, 26*, 83–89. https://doi.org/10.1016/j.bodyim.2018.06.005

Bianchi, D., Morelli, M., Baiocco, R., & Chirumbolo, A. (2017). Sexting as the mirror on the wall: Body-esteem attribution, media models, and objectified-body consciousness. *Journal of Adolescence, 61*, 164–172. https://doi.org/10.1016/j.adolescence.2017.10.006

Boberová, Z., & Husárová, D. (2021). What role does body image in relationship between level of health literacy and symptoms of eating disorders in adolescents? *International Journal of Environmental Research and Public Health, 18*(7), Article 3482. https://doi.org/10.3390/ijerph18073482

Bornioli, A., Lewis-Smith, H., Smith, A., Slater, A., & Bray, I. (2019). Adolescent body dissatisfaction and disordered eating: Predictors of later risky health behaviours. *Social Science & Medicine, 238*, Article 112458. https://doi.org/10.1016/j.socscimed.2019.112458

Califano, G., Capasso, M., & Caso, D. (2022). Exploring the roles of online moral disengagement, body esteem, and psychosexual variables in predicting sexting motivations and behaviours. *Computers in Human Behavior, 129*, Article 107146. https://doi.org/10.1016/j.chb.2021.107146

Calvete, E., Orue, I., & Gámez-Guadix, M. (2022). A preventive intervention to reduce risk of online grooming among adolescents. *Psychosocial Intervention, 31*(3), 177–184. https://doi.org/10.5093/pi2022a14

Cary, K. M., Maas, M. K., & Bowles, R. P. (2024). Development and validation of the Online Sexual Objectification Experiences Scale among college women. *Psychology of Women Quarterly, 48*(3), 443–459. https://doi.org/10.1177/03616843241250295

Choukas-Bradley, S., Nesi, J., Widman, L., & Galla, B. M. (2020). The Appearance-Related Social Media Consciousness Scale: Development and validation with adolescents. *Body Image, 33*, 164–174. https://doi.org/10.1016/j.bodyim.2020.02.017

606 Cox, A. E., Ullrich-French, S., Cole, A. N., & D'Hondt-Taylor, M. (2016). The role
607 of state mindfulness during yoga in predicting self-objectification and reasons
608 for exercise. *Psychology of Sport and Exercise, 22*, 321–327.
609 https://doi.org/10.1016/j.psychsport.2015.10.001
610 Dadaczynski, K., Rathmann, K., Schricker, J., Bilz, L., Sudeck, G., Fischer, S. M.,
611 Janiczek, O., & Quilling, E. (2022). Digitale Gesundheitskompetenz von
612 Schülerinnen und Schülern. Ausprägung und Assoziationen mit dem
613 Bewegungs- und Ernährungsverhalten [Digital health literacy of pupils: Level
614 and associations with physical activity and dietary behavior].
615 *Bundesgesundheitsblatt—Gesundheitsforschung—Gesundheitsschutz, 65*(7–8),
616 784–794. https://doi.org/10.1007/s00103-022-03548-5
617 Daley, A. J., Copeland, R. J., Wright, N. P., Roalfe, A., & Wales, J. K. H. (2006).
618 Exercise therapy as a treatment for psychopathologic conditions in obese and
619 morbidly obese adolescents: A randomized, controlled trial. *Pediatrics, 118*(5),
620 2126–2134. https://doi.org/10.1542/peds.2006-1285
621 Daniels, E. A., Zurbriggen, E. L., & Ward, L. M. (2020). Becoming an object: A
622 review of self-objectification in girls. *Body Image, 33*, 278–299.
623 https://doi.org/10.1016/j.bodyim.2020.02.016
624 Daubenmier, J. J. (2005). The relationship of yoga, body awareness, and body
625 responsiveness to self-objectification and disordered eating. *Psychology of*
626 *Women Quarterly, 29*(2), 207–219.
627 https://doi.org/10.1111/j.1471-6402.2005.00183.x

De Vries, D. A., Peter, J., de Graaf, H., & Nikken, P. (2016). Adolescents' social network site use, peer appearance-related feedback, and body dissatisfaction: Testing a mediation model. *Journal of Youth and Adolescence, 45*(1), 211–224. https://doi.org/10.1007/s10964-015-0266-4

Du, X.-Y., Wang, L., Zuo, Y.-F., Wu, Q., Qian, Y.-L., & Ma, R. (2023). Association between physical activity and online sexual objectification experience: The mediating role of body-image depression. *Frontiers in Psychology, 13*, Article 1049588. https://doi.org/10.3389/fpsyg.2022.1049588

Ferreiro, F., Seoane, G., & Senra, C. (2012). Gender-related risk and protective factors for depressive symptoms and disordered eating in adolescence: A 4-year longitudinal study. *Journal of Youth and Adolescence, 41*(5), 607–622. https://doi.org/10.1007/s10964-011-9718-7

Fleary, S. A., Joseph, P., & Pappagianopoulos, J. E. (2018). Adolescent health literacy and health behaviors: A systematic review. *Journal of Adolescence, 62*, 116–127. https://doi.org/10.1016/j.adolescence.2017.11.010

Fox, K. R., & Corbin, C. B. (1989). The physical self-perception profile: Devlopment and preliminary validation. *Journal of Sport and Exercise Psychology, 11*(4), 408–430. https://doi.org/10.1123/jsep.11.4.408

Franzoi, S. L., & Shields, S. A. (1984). The body esteem scale: Multidimensional structure and sex differences in a college population. *Journal of Personality Assessment, 48*(2), 173–178. https://doi.org/10.1207/s15327752jpa4802_12

649 Fredrickson, B. L., & Roberts, T.-A. (1997). Objectification theory: Toward
650 understanding women's lived experiences and mental health risks. *Psychology*
651 *of Women Quarterly, 21*(2), 173–206.
652 https://doi.org/10.1111/j.1471-6402.1997.tb00108.x
653 Freeman, J. L., Caldwell, P. H. Y., Bennett, P. A., & Scott, K. M. (2018). How
654 adolescents search for and appraise online health information: A systematic
655 review. *The Journal of Pediatrics, 195*, 244–255.e1.
656 https://doi.org/10.1016/j.jpeds.2017.11.031
657 Gai, G., Ahmad, N. S., & Yang, F. (2026). Online sexual objectification experiences
658 and academic achievement: Behavioral engagement as a mediator and
659 emotional intelligence as a moderator. *Acta Psychologica, 267*, Article 107184.
660 https://doi.org/10.1016/j.actpsy.2026.107184
661 Gothe, N. P., Erlenbach, E., & Engels, H.-J. (2022). Exercise and self-esteem model:
662 Validity in a sample of healthy female adolescents. *Current Psychology,*
663 *41*(12), 8876–8884. https://doi.org/10.1007/s12144-021-01390-7
664 Guo, S. J., Yu, X. M., Sun, Y. Y., Nie, D., Li, X. M., & Wang, L. (2013). eHEALS
665 jiankang suyang liangbiao de hanhua ji shiyongxing tansuo [Adaptation and
666 evaluation of Chinese version of eHEALS and its usage among senior high
667 school students]. *Chinese Journal of Health Education, 29*(2), 106–108, 123.
668 Haugen, T., Säfvenbom, R., & Ommundsen, Y. (2011). Physical activity and global
669 self-worth: The role of physical self-esteem indices and gender. *Mental Health*
670 *and Physical Activity, 4*(2), 49–56. https://doi.org/10.1016/j.mhpa.2011.07.001

671 Hnidková, L., Bakalár, P., Magda, R., Kolarčik, P., Kopčáková, J., & Boberová, Z.
672 (2024). Adolescents' health literacy is directly associated with their physical
673 activity but indirectly with their body composition and cardiorespiratory
674 fitness: Mediation analysis of the Slovak HBSC study data. *BMC Public*
675 *Health, 24*(1), Article 2762. https://doi.org/10.1186/s12889-024-20227-z
676 Inchley, J., Kirby, J., & Currie, C. (2011). Longitudinal changes in physical
677 self-perceptions and associations with physical activity during adolescence.
678 *Pediatric Exercise Science, 23*(2), 237–249.
679 https://doi.org/10.1123/pes.23.2.237
680 Jankauskiene, R., & Baceviciene, M. (2022). Adolescent girls' participation in sports
681 is associated with lower negative effects of internalization of thin body ideals
682 on self-objectification: Findings from a cross-sectional study. *Eating and*
683 *Weight Disorders—Studies on Anorexia, Bulimia and Obesity, 27*(8), 3289–
684 3300. https://doi.org/10.1007/s40519-022-01459-7
685 Ji, J., Xiang, X., Chen, R., Chen, Z., & Yan, J. (2023). Pathways from media attention
686 and peer communication to body dissatisfaction: The moderating role of
687 protective filtering. *BMC Psychology, 11*(1), Article 447.
688 https://doi.org/10.1186/s40359-023-01491-x
689 Jiang, S., Ng, J. Y. Y., Choi, S. M., & Ha, A. S. (2024). Relationships among eHealth
690 literacy, physical literacy, and physical activity in Chinese university students:
691 Cross-sectional study. *Journal of Medical Internet Research, 26*, Article
692 e56386. https://doi.org/10.2196/56386

693 Kahlin, Y., Werner, S., Edman, G., Raustorp, A., & Alricsson, M. (2016). Physical
694 self-esteem and personality traits in Swedish physically inactive female high
695 school students: An intervention study. *International Journal of Adolescent*
696 *Medicine and Health, 28*(4), 363–372.
697 https://doi.org/10.1515/ijamh-2015-0017
698 Kim, K., Shin, S., Kim, S., & Lee, E. (2023). The relation between eHealth literacy
699 and health-related behaviors: Systematic review and meta-analysis. *Journal of*
700 *Medical Internet Research, 25*, Article e40778. https://doi.org/10.2196/40778
701 Kurz, M., Rosendahl, J., Rodeck, J., Muehleck, J., & Berger, U. (2022). School-based
702 interventions improve body image and media literacy in youth: A systematic
703 review and meta-analysis. *Journal of Prevention, 43*(1), 5–23.
704 https://doi.org/10.1007/s10935-021-00660-1
705 Kvardova, N., Literova, A., & Machackova, H. (2026). Exploring resilience as a
706 moderator of social media appearance activity and body image concerns in
707 adolescents. *Scientific Reports, 16*(1), Article 16171.
708 https://doi.org/10.1038/s41598-026-45442-z
709 Liang, D. (1994). Gaoxiao xuesheng yingji shuiping ji qi yu tiyu duanlian de guanxi
710 [Stress levels of college students and their relationship with physical exercise].
711 *Chinese Mental Health Journal, 8*(1), 5–6.
712 Linardon, J., Messer, M., & Tylka, T. L. (2023). Functionality appreciation and its
713 correlates: Systematic review and meta-analysis. *Body Image, 45*, 65–72.
714 https://doi.org/10.1016/j.bodyim.2023.02.002

715 Liu, H. X., Chow, B. C., Hassel, H., Huang, Y. W., Liang, W., & Wang, R. B. (2024).
716 Prospective association of eHealth literacy and health literacy with physical
717 activity among Chinese college students: A multiple mediation analysis.
718 *Frontiers in Public Health, 12*, Article 1275691.
719 https://doi.org/10.3389/fpubh.2024.1275691
720 Longobardi, C., Fabris, M. A., Prino, L. E., & Settanni, M. (2021). The role of body
721 image concerns in online sexual victimization among female adolescents: The
722 mediating effect of risky online behaviors. *Journal of Child & Adolescent*
723 *Trauma, 14*(1), 51–60. https://doi.org/10.1007/s40653-020-00301-5
724 Luo, Y. J. (2017). *The influence of objectification experiences in online socialization*
725 *on female college students' sense of objectification* [Master's thesis, Central
726 China Normal University]. China National Knowledge Infrastructure.
727 Luo, Y.-J., Zhang, J.-Q., Nie, Q., & Chen, H. (2026). Who objectifies girls on social
728 media? The associations between ambivalent sexism and online sexual
729 objectification: A 13-month prospective study. *Humanities and Social*
730 *Sciences Communications, 13*(1), Article 920.
731 https://doi.org/10.1057/s41599-026-07254-4
732 Mahdifar, M., Tavakoly Sany, S. B., Ghavami, V., & Vahedian-Shahroodi, M. (2021).
733 Health literacy and body image concern among healthcare employees in
734 Binaloud, Iran. *Journal of Health Literacy, 6*(1), 31–40.
735 https://doi.org/10.22038/jhl.2021.55849.1153

Mahlo, L., & Tiggemann, M. (2016). Yoga and positive body image: A test of the embodiment model. *Body Image, 18*, 135–142. https://doi.org/10.1016/j.bodyim.2016.06.008

McLean, S. A., Paxton, S. J., & Wertheim, E. H. (2013). Mediators of the relationship between media literacy and body dissatisfaction in early adolescent girls: Implications for prevention. *Body Image, 10*(3), 282–289. https://doi.org/10.1016/j.bodyim.2013.01.009

McLean, S. A., Paxton, S. J., & Wertheim, E. H. (2016). Does media literacy mitigate risk for reduced body satisfaction following exposure to thin-ideal media? *Journal of Youth and Adolescence, 45*(8), 1678–1695. https://doi.org/10.1007/s10964-016-0440-3

McLean, S. A., Wertheim, E. H., Masters, J., & Paxton, S. J. (2017). A pilot evaluation of a social media literacy intervention to reduce risk factors for eating disorders. *International Journal of Eating Disorders, 50*(7), 847–851. https://doi.org/10.1002/eat.22708

Melby, P. S., Elsborg, P., Bentsen, P., & Nielsen, G. (2023). Cross-sectional associations between adolescents' physical literacy, sport and exercise participation, and wellbeing. *Frontiers in Public Health, 10*, Article 1054482. https://doi.org/10.3389/fpubh.2022.1054482

Mendelson, B. K., Mendelson, M. J., & White, D. R. (2001). Body-esteem scale for adolescents and adults. *Journal of Personality Assessment, 76*(1), 90–106. https://doi.org/10.1207/S15327752JPA7601_6

758 Michie, S., van Stralen, M. M., & West, R. (2011). The behaviour change wheel: A
759 new method for characterising and designing behaviour change interventions.
760 *Implementation Science, 6*(1), Article 42.
761 https://doi.org/10.1186/1748-5908-6-42
762 Mitsutake, S., Shibata, A., Ishii, K., & Oka, K. (2016). Associations of eHealth
763 literacy with health behavior among adult internet users. *Journal of Medical*
764 *Internet Research, 18*(7), Article e192. https://doi.org/10.2196/jmir.5413
765 Moradi, B., & Huang, Y.-P. (2008). Objectification theory and psychology of women:
766 A decade of advances and future directions. *Psychology of Women Quarterly,*
767 *32*(4), 377–398. https://doi.org/10.1111/j.1471-6402.2008.00452.x
768 Nesi, J., Choukas-Bradley, S., & Prinstein, M. J. (2018). Transformation of adolescent
769 peer relations in the social media context: Part 1—A theoretical framework
770 and application to dyadic peer relationships. *Clinical Child and Family*
771 *Psychology Review, 21*(3), 267–294.
772 https://doi.org/10.1007/s10567-018-0261-x
773 Norman, C. D., & Skinner, H. A. (2006). eHEALS: The eHealth Literacy Scale.
774 *Journal of Medical Internet Research, 8*(4), Article e27.
775 https://doi.org/10.2196/jmir.8.4.e27
776 O'Hara, S. E., Cox, A. E., & Amorose, A. J. (2014). Emphasizing appearance versus
777 health outcomes in exercise: The influence of the instructor and participants'
778 reasons for exercise. *Body Image, 11*(2), 109–118.
779 https://doi.org/10.1016/j.bodyim.2013.12.004

780 Ojala, K., Huotari, P., Villberg, J., & Tynjälä, J. (2021). The associations between
781 physical activity and body-esteem in 15-year-old adolescents: A
782 cross-sectional study from Finland. *Physical Activity and Health, 5*(1), 154–
783 165. https://doi.org/10.5334/paah.107
784 Ørstavik, E. K., Strandberg-Larsen, K., Nordentoft, M., Karstoft, K.-I., & Madsen, T.
785 (2026). Body dissatisfaction and adolescence suicidality—Results from the
786 Danish national birth cohort. *Journal of Psychiatric Research, 201*, 391–399.
787 https://doi.org/10.1016/j.jpsychires.2026.06.038
788 Paquette, M.-M., Dion, J., Bőthe, B., Girouard, A., & Bergeron, S. (2022).
789 Heterosexual, cisgender and gender and sexually diverse adolescents' sexting
790 behaviors: The role of body appreciation. *Journal of Youth and Adolescence,*
791 *51*(2), 278–290. https://doi.org/10.1007/s10964-021-01568-z
792 Paxton, S. J., McLean, S. A., & Rodgers, R. F. (2022). "My critical filter buffers your
793 app filter": Social media literacy as a protective factor for body image. *Body*
794 *Image, 40*, 158–164. https://doi.org/10.1016/j.bodyim.2021.12.009
795 Peng, B., Chen, W., Wang, H., & Yu, T. (2025). From physical self-esteem to sports
796 participation: The mediating role of exercise motivation and social support in
797 adolescents. *PLOS ONE, 20*(5), Article e0324588.
798 https://doi.org/10.1371/journal.pone.0324588
799 Piran, N., Teall, T. L., & Counsell, A. (2020). The experience of embodiment scale:
800 Development and psychometric evaluation. *Body Image, 34*, 117–134.
801 https://doi.org/10.1016/j.bodyim.2020.05.007

802 Quayle, E. (2020). Prevention, disruption and deterrence of online child sexual
803 exploitation and abuse. *ERA Forum, 21*(3), 429–447.
804 https://doi.org/10.1007/s12027-020-00625-7
805 Raudsepp, L., Neissaar, I., & Kull, M. (2013). A longitudinal assessment of the links
806 between physical activity and physical self-worth in adolescent females.
807 *European Journal of Sport Science, 13*(6), 716–722.
808 https://doi.org/10.1080/17461391.2013.775349
809 Reichert, T., LaTour, M. S., Lambiase, J. J., & Adkins, M. (2007). A test of media
810 literacy effects and sexual objectification in advertising. *Journal of Current*
811 *Issues & Research in Advertising, 29*(1), 81–92.
812 https://doi.org/10.1080/10641734.2007.10505210
813 Rodgers, R. F., McLean, S. A., & Paxton, S. J. (2015). Longitudinal relationships
814 among internalization of the media ideal, peer social comparison, and body
815 dissatisfaction: Implications for the tripartite influence model. *Developmental*
816 *Psychology, 51*(5), 706–713. https://doi.org/10.1037/dev0000013
817 Saunders, J. F., Nutter, S., Waugh, R., & Hayden, K. A. (2024). Testing body-related
818 components of objectification theory: A meta-analysis of the relations between
819 body shame, self-objectification, and body dissatisfaction. *Body Image, 50*,
820 Article 101738. https://doi.org/10.1016/j.bodyim.2024.101738

821 Scull, T. M., Dodson, C. V., Geller, J. G., Reeder, L. C., & Stump, K. N. (2022). A
822 media literacy education approach to high school sexual health education:
823 Immediate effects of Media Aware on adolescents' media, sexual health, and
824 communication outcomes. *Journal of Youth and Adolescence, 51*(4), 708–723.
825 https://doi.org/10.1007/s10964-021-01567-0
826 Slater, A., & Tiggemann, M. (2012). Time since menarche and sport participation as
827 predictors of self-objectification: A longitudinal study of adolescent girls. *Sex*
828 *Roles, 67*(9–10), 571–581. https://doi.org/10.1007/s11199-012-0200-0
829 Sollerhed, A.-C., Fransson, J., Skoog, I., & Garmy, P. (2022). Physical activity levels,
830 perceived body appearance, and body functioning in relation to perceived
831 wellbeing among adolescents. *Frontiers in Sports and Active Living, 4*, Article
832 830913. https://doi.org/10.3389/fspor.2022.830913
833 Sonstroem, R. J., & Morgan, W. P. (1989). Exercise and self-esteem: Rationale and
834 model. *Medicine & Science in Sports & Exercise, 21*(3), 329–337.
835 https://doi.org/10.1249/00005768-198906000-00018
836 Steinsbekk, S., Wichstrøm, L., Stenseng, F., Nesi, J., Hygen, B. W., & Skalická, V.
837 (2021). The impact of social media use on appearance self-esteem from
838 childhood to adolescence—A 3-wave community study. *Computers in Human*
839 *Behavior, 114*, Article 106528. https://doi.org/10.1016/j.chb.2020.106528

Taba, M., Allen, T. B., Caldwell, P. H. Y., Skinner, S. R., Kang, M., McCaffery, K., & Scott, K. M. (2022). Adolescents' self-efficacy and digital health literacy: A cross-sectional mixed methods study. *BMC Public Health, 22*(1), Article 1223. https://doi.org/10.1186/s12889-022-13599-7

Tamarit, A., Schoeps, K., Peris-Hernández, M., & Montoya-Castilla, I. (2021). The impact of adolescent internet addiction on sexual online victimization: The mediating effects of sexting and body self-esteem. *International Journal of Environmental Research and Public Health, 18*(8), Article 4226. https://doi.org/10.3390/ijerph18084226

Tamplin, N. C., McLean, S. A., & Paxton, S. J. (2018). Social media literacy protects against the negative impact of exposure to appearance ideal social media images in young adult women but not men. *Body Image, 26*, 29–37. https://doi.org/10.1016/j.bodyim.2018.05.003

Vandenbosch, L., & van Oosten, J. M. F. (2017). The relationship between online pornography and the sexual objectification of women: The attenuating role of porn literacy education. *Journal of Communication, 67*(6), 1015–1036. https://doi.org/10.1111/jcom.12341

van Kessel, R., Wong, B. L. H., Clemens, T., & Brand, H. (2022). Digital health literacy as a super determinant of health: More than simply the sum of its parts. *Internet Interventions, 27*, Article 100500. https://doi.org/10.1016/j.invent.2022.100500

Voelker, D. K., Reel, J. J., & Greenleaf, C. (2015). Weight status and body image perceptions in adolescents: Current perspectives. *Adolescent Health, Medicine and Therapeutics, 6*, 149–158. https://doi.org/10.2147/ahmt.s68344

Wang, Y., Gu, X., Geng, J., Wei, X., & Lei, L. (2024). Relationships among selfie-viewing on social media, thin-ideal internalization, and restrained eating in adolescents: The buffering role of media literacy. *Cyberpsychology: Journal of Psychosocial Research on Cyberspace, 18*(1), Article 2. https://doi.org/10.5817/CP2024-1-2

Ward, L. M., Daniels, E. A., Zurbriggen, E. L., & Rosenscruggs, D. (2023). The sources and consequences of sexual objectification. *Nature Reviews Psychology, 2*(8), 496–513. https://doi.org/10.1038/s44159-023-00192-x

Xu, R., Jiang, J., Yin, Z., Zhong, Q., Liu, D., Sun, M., & Xiong, M. (2026). The association between digital health literacy and healthy lifestyle behaviors among youth: Systematic review of cross-sectional studies. *Digital Health, 12*, Article 20552076261456577. https://doi.org/10.1177/20552076261456577

Xu, X., & Yao, J. (2001). Daxuesheng shenti zizun liangbiao de xiuding yu jianyan [Revision and validation of the physical self-esteem scale for college students]. *China Sport Science, 21*(2), 78–81.

Yang, H., Wang, J. J., Tng, G. Y. Q., & Yang, S. (2020). Effects of social media and smartphone use on body esteem in female adolescents: Testing a cognitive and affective model. *Children, 7*(9), Article 148. https://doi.org/10.3390/children7090148

Zangger, G., Mortensen, S. R., Tang, L. H., Thygesen, L. C., & Skou, S. T. (2024). Association between digital health literacy and physical activity levels among individuals with and without long-term health conditions: Data from a cross-sectional survey of 19,231 individuals. *Digital Health, 10*, Article 20552076241233158. https://doi.org/10.1177/20552076241233158

Zhang, Y., Wen, Z., Zhu, Y., & Guan, G. (2024). Effects of physical exercise on body esteem among females: A meta-analysis. *BMC Public Health, 24*(1), Article 3387. https://doi.org/10.1186/s12889-024-20861-7

Zhu, Y., Du, Z., Zhang, Y., Li, X., & Meng, J. (2025). A study of the symptom network structure of internet addiction, non-suicidal self-injury and internalization problems in adolescents and its association with physical activity. *BMC Public Health, 25*(1), Article 4065. https://doi.org/10.1186/s12889-025-25370-9

Zhu, Y., Du, Z., Zhang, Y., Li, X., & Wen, Z. (2026). The relationship between digital health literacy and mental health promotion behaviors among Chinese older adults: Exploring the mediating role of health beliefs. *BMC Geriatrics, 26*(1), Article 407. https://doi.org/10.1186/s12877-026-07209-z

Zhu, Y., Li, X., & Du, Z. (2025). Effects of physical activity on internalizing problems in adolescents with autism spectrum disorder: The chain mediating effects of sport friendship quality and social-emotional competence. *Frontiers in Psychology, 16*, Article 1626831. https://doi.org/10.3389/fpsyg.2025.1626831

Zhao, C., Zhu, Y., Zhang, Y., Cui, B., Liu, T., Shen, X., & Yu, S. (2026). The relationship between digital health literacy and problematic mobile social media use among adolescents: The chain mediating role of physical activity and social–emotional competence. *Frontiers in Psychology*, 17, Article 1801252. https://doi.org/10.3389/fpsyg.2026.1801252

Zhang, K., Liu, M., Yin, Z., Kong, N., & Gong, H. (2025). The effect of exercise motivation on adolescents' subjective well-being: Chain mediation of physical activity and social-emotional competency. *BMC Public Health*, 25, Article 1698. https://doi.org/10.1186/s12889-025-22965-0

Zhu, Y., Lyu, J., Wang, X., Zhao, C., Li, K., Song, H., & Wang, Y. (2026). How negative life events and emotion regulation difficulties are associated with non-suicidal self-injury in adolescents: A dimension-level network analysis and the role of physical activity. *Journal of Affective Disorders.* Advance online publication. https://doi.org/10.1016/j.jad.2026.122448

Zuair, A. A., & Sopory, P. (2022). Effects of media health literacy school-based interventions on adolescents' body image concerns, eating concerns, and thin-internalization attitudes: A systematic review and meta-analysis. *Health Communication, 37*(1), 20–28. https://doi.org/10.1080/10410236.2020.1813954