Journal Website

Article history:
Received 10 May 2026
Revised 15 July 2026
Accepted 23 July 2026
Published online 30 July 2026

International Journal of Education and Cognitive Sciences

Volume 7, Issue 3, pp 1-13

E-ISSN: 3041-8828

Problematic Smartphone Use Among Adolescent Girls: Dark Triad Traits and the Mediating Role of Loneliness

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A r t i c l e I n f o

Article type:
Original Research

How to cite this article:
Jamali, R., Pirani, Z., Davoodi, H., & Abbasi, M. (2026). Problematic Smartphone Use Among Adolescent Girls: Dark Triad Traits and the Mediating Role of Loneliness. *International Journal of Education and Cognitive Sciences, 7*(3), 1-13.
https://doi.org/10.61838/kman.ijecs.454

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A B S T R A C T

Purpose: This study examined the direct and indirect associations of the Dark Triad traits (Machiavellianism, narcissism, and psychopathy) with problematic smartphone use (PSU) through loneliness among adolescent girls.

Methods and Materials: A cross-sectional correlational study included 479 girls in Grades 10–12 (mean age = 16.47, SD = 0.78), convenience-sampled from four regular public girls' upper-secondary schools across four districts of Tehran, Iran, in 2025–2026. Participants completed Persian forms of the Dirty Dozen, UCLA Loneliness Scale Version 3, and Smartphone Addiction Scale–Short Version. Item-level confirmatory factor analysis and structural equation modeling (SEM) used weighted least squares mean- and variance-adjusted (WLSMV) estimation; indirect effects were assessed with 5,000-resample percentile bootstrapping in an auxiliary diagonally weighted least squares (DWLS) model.

Findings: Psychopathy was positively and narcissism negatively associated with loneliness, whereas Machiavellianism was not. Loneliness, Machiavellianism, and narcissism were positively associated with PSU, but the direct psychopathy path was nonsignificant. Only psychopathy showed a significant indirect association with PSU through loneliness ($\beta = 0.076$, 95% bootstrap CI [0.037, 0.176]); its total association was nonsignificant. Full mediation fit worse than partial mediation ($\Delta\chi^2(3) = 155.45$, $p < 0.001$), whereas removing the direct psychopathy–PSU path did not worsen fit ($\Delta\chi^2(1) = 0.47$, $p = 0.494$).

Conclusion: Findings indicate trait-specific associations between Dark Triad traits and PSU among adolescent girls. Loneliness may represent a psychopathy-specific statistical pathway, supporting trait-level examination of personality-related associations with PSU.

Keywords: *Problematic smartphone use, Machiavellianism, Narcissism, Psychopathy, Loneliness*

1. Introduction

Smartphones are now integrated into adolescents' everyday lives (Gerosa et al., 2022) and are used for communication and social interaction, information seeking, learning, and entertainment (Huang et al., 2023). Alongside these widespread uses, problematic smartphone use (PSU) has emerged as a public health concern among adolescents (Giansanti, 2025). PSU broadly refers to a pattern of smartphone use that is difficult to control and impairs daily functioning (Busch & McCarthy, 2021), whereas frequent or prolonged use alone does not necessarily indicate PSU (Panova & Carbonell, 2018).

Despite this distinction, conceptualizing PSU as a behavioral addiction remains contested (James et al., 2023). Proponents argue that severe PSU may show addiction-like features of impaired control, persistence despite adverse consequences, and functional impairment (Lin et al., 2016; Yu & Sussman, 2020); evidence also indicates cognitive and neurobiological alterations in inhibitory control, decision-making, cue reactivity, and reward processing (Liu et al., 2024; Wolf et al., 2025). In contrast, Billieux et al. (2015) proposed multiple pathways to problematic phone use and argued that not all warrant conceptualization as behavioral addiction. Critics view smartphone addiction as an overly broad label that collapses heterogeneous, application-mediated patterns into a single disorder and risks classifying problematic but nonclinical use as addiction (Demetrovics et al., 2026; Domoff et al., 2025; Panova & Carbonell, 2018). More recently, Meshi and Binder (2026) argued that the smartphone is a vehicle for delivering rewards rather than the target of addiction. Given this unresolved debate, the present study conceptualizes PSU along a severity continuum; severe cases may exhibit addiction-like features, but PSU is not treated as a formally recognized addictive disorder.

Within this dimensional framework, age-comparative studies suggest that PSU may be elevated at some stages of adolescence relative to child and older comparison groups (Cai et al., 2021; Jo et al., 2018), although generational findings indicate heterogeneity across age-defined cohorts (Wickord & Quaiser-Pohl, 2022). This apparent vulnerability may reflect multiple factors, with those considered here representing only a subset supported by current evidence (Crowhurst & Hosseinzadeh, 2024; Hu et al., 2026; León Méndez et al., 2024). Ongoing maturation of cognitive-control systems, combined with heightened sensitivity to immediate and socially salient rewards, may make rewarding digital activities harder to regulate during adolescence (Marciano et al., 2021). Higher initial self-regulation predicted a slower increase in PSU across adolescence (Xiao et al., 2025), whereas emotion dysregulation has been associated with greater PSU among adolescents (Giordano et al., 2021). Interpersonal factors may also contribute: lower perceived competence in close friendships and more frequent passive checking of social media messages prospectively predicted PSU (Su et al., 2022).

Adolescents' vulnerability to PSU may also vary by gender. Evidence, however, remains mixed. A broad meta-analysis found no significant pooled difference in PSU prevalence between females and males (Lu et al., 2024), whereas an adolescent-focused systematic review found that more studies reported higher levels among girls than boys (Cilligol Karabey et al., 2024). In a Korean adolescent sample, girls were more likely than boys to be classified as potential-risk or high-risk smartphone users (Lee & Lee, 2017). Female gender was also associated with greater PSU symptoms in German adolescents (Kliesener et al., 2022) and with a greater likelihood of problematic-user status in Spanish adolescents (Extremera et al., 2019). Moreover, German data showed a stronger increase in PSU symptoms among girls than boys from 2018 to 2023 (Poulain et al., 2025). Gender differences may also extend beyond prevalence to the correlates and forms of PSU, as comparable prevalence but different usage-related and psychological correlates have been reported across sexes (Chen et al., 2017). These findings support focused investigation of adolescent girls while indicating that gender differences are context-dependent and cannot be attributed to a single mechanism.

The developmental and gender-related evidence above supports closer examination of PSU among adolescent girls. To account for individual differences in vulnerability, the present study draws on the Interaction of Person-Affect-Cognition-Execution (I-PACE) model (Brand et al., 2019). In I-PACE, person-related predispositions interact with affective and cognitive responses and executive control processes in the development and maintenance of addictive behavior patterns. Because I-PACE was formulated as an etiological model of addictive behaviors (Brand et al., 2025), its process assumptions are used here selectively to organize hypothesized associations with PSU rather than to establish PSU as a formally recognized addictive disorder. The Dark Triad traits, Machiavellianism, narcissism, and psychopathy, can be treated as person-related predispositions relevant to

E-ISSN: 3041-8828

PSU, although their empirical associations differ by trait (Balta et al., 2019; Servidio et al., 2021). Machiavellianism is characterized by manipulativeness, cynicism, callous affect, and a strategic-calculating orientation; narcissism by grandiosity, entitlement, dominance, and superiority; and psychopathy by callousness, impulsivity, thrill seeking, and low empathy and low anxiety (Jones & Paulhus, 2014; Paulhus & Williams, 2002).

Beyond personality-related predispositions, I-PACE includes social cognitions among person-related characteristics and proposes that they may interact with coping styles and Internet-related cognitive biases to shape affective and cognitive responses. Loneliness is one such social cognition, linked in I-PACE to excessive use of Internet applications with communication features (Brand et al., 2016). Loneliness is a distressing subjective experience associated with the perception that one's social needs are not adequately met by the quantity or, particularly, the quality of one's social relationships (Hawkley & Cacioppo, 2010). Although the original I-PACE model situates loneliness among person-related social cognitions, later studies have treated it as an affective component (Mehmood et al., 2021) or an affective pathway to smartphone addiction (Kim et al., 2026). A meta-analysis found a positive association between loneliness and smartphone addiction among adolescents (Ge et al., 2025), and a large population-based study linked greater loneliness to a higher likelihood of PSU (Kim & Cho, 2026). Adolescent studies have also identified negative emotions and maladaptive coping (Du et al., 2023), and upward social comparison and fear of missing out (Shao et al., 2024), as statistical mediators between loneliness and PSU. Dark Triad traits show different associations with loneliness: Machiavellianism and psychopathy are generally linked to greater loneliness, whereas narcissism shows weaker, null, or inverse associations (Pu & Gan, 2026; Tomii & Oshio, 2024; Zhang et al., 2015). These findings suggest that loneliness may represent an affective pathway linking Dark Triad traits to PSU, although this mediating role has received limited direct examination.

Emerging research has examined psychological mechanisms that may mediate associations between Dark Triad traits and PSU, including fearful attachment (Balta et al., 2019), fear of missing out (Servidio et al., 2021), and metacognitive beliefs (Pirzade et al., 2024). However, to the best of our knowledge, no previous study has directly tested loneliness as a mediator of the associations between each of the three Dark Triad traits and PSU. To address this gap, we simultaneously tested a partial mediation model among adolescent girls attending public high schools in Tehran, Iran, with Machiavellianism, narcissism, and psychopathy as distinct predictors, loneliness as the mediator, and PSU as the outcome. We hypothesized direct associations of each Dark Triad trait with loneliness and PSU, a direct association between loneliness and PSU, and indirect associations of each trait with PSU through loneliness. We also examined whether the proposed partial mediation model adequately fit the data.

2. Methods and Materials

2.1. Study Design and Participants

This cross-sectional correlational study was conducted during the 2025–2026 academic year. The target population comprised female students in Grades 10–12 attending general upper secondary schools in Tehran. Participants were recruited by nonprobability convenience sampling from four regular public girls' upper secondary schools in four different Tehran districts. The schools were selected based on accessibility and permission from school administrators. All students present in available Grades 10–12 classes who met the eligibility criteria were invited to participate.

Eligibility criteria included enrollment in one of the selected schools, ownership and use of a smartphone, and the ability to read and complete Persian-language questionnaires. Data were collected in person using paper-and-pencil self-report questionnaires. School administrators and teachers coordinated the distribution and collection of the questionnaires, and students were instructed to complete them carefully.

A pragmatic 10:1 participant-to-item ratio across 42 items set the initial benchmark at 420 (Chomeya et al., 2024). The target was raised to 500 to allow for exclusions and broadly aligned with simulation evidence for robust weighted least squares estimation in confirmatory factor analysis (CFA) with ordinal indicators at this ratio and structural equation modeling (SEM) with mixed indicators at N = 500 (DiStefano et al., 2019; Li, 2021).

Permission to administer the questionnaires was obtained from the participating school authorities. Before administration, students were informed of the study purpose, voluntary participation, their right to decline or discontinue without penalty, and the confidentiality of their responses. Only students who voluntarily agreed to participate received a questionnaire set. No names or other direct identifiers were collected; data were used solely for research purposes.

E-ISSN: 3041-8828

2.2. Data Collection Tools

The Dirty Dozen (Jonason & Webster, 2010) is a 12-item self-report measure of Machiavellianism, narcissism, and psychopathy, comprising three four-item subscales. An adapted Persian version was used in this study. Its wording was prepared by comparing the original English items with two previously evaluated Persian versions that showed evidence of reliability and a three-dimensional structure broadly consistent with the original measure (Hajloo et al., 2016; Yousefi & Piri, 2016). Three psychology faculty members and an English-language specialist then reviewed the Persian wording for conceptual equivalence, clarity, and comprehensibility for adolescents. For administration, Items 1–4 assessed Machiavellianism, 5–8 narcissism, and 9–12 psychopathy. Psychopathy items were placed last because their wording was considered comparatively more negative and sensitive for adolescent respondents; only presentation order changed, not subscale composition or scoring. Consistent with the 5-point response format used by Hajloo et al. (2016), and to facilitate responding among adolescents, items were rated from 1 (strongly disagree) to 5 (strongly agree). All items were scored in the same direction, yielding subscale scores of 4–20, with higher scores indicating higher levels of the corresponding trait. The original validation supported a three-factor structure; in the final validation study, Cronbach's alpha coefficients were 0.79, 0.84, and 0.77 for Machiavellianism, narcissism, and psychopathy, respectively (Jonason & Webster, 2010). In the present sample, the corresponding coefficients were 0.83, 0.89, and 0.72.

The UCLA Loneliness Scale Version 3 (Russell, 1996) is a 20-item self-report instrument assessing subjective feelings of loneliness and social isolation. The validated Persian version was used in this study (Zarei et al., 2016). It comprises 11 negatively worded and nine positively worded items. Participants rated how often they felt as described on a 4-point frequency scale from 1 (never) to 4 (always). Items 1, 5, 6, 9, 10, 15, 16, 19, and 20 were reverse-scored; summed scores range from 20 to 80, with higher scores indicating greater loneliness. In the initial validation of Version 3, Cronbach's alpha ranged from 0.89 to 0.94 across samples, and confirmatory factor analyses supported a global bipolar loneliness factor and two wording-method factors, with all three factors specified as orthogonal (Russell, 1996). In the Persian validation, a three-factor model comprising global, negative-item, and positive-item factors showed the best fit; total-score Cronbach's alpha was 0.91 and the 1-month intraclass correlation coefficient was 0.93 (Zarei et al., 2016). Cronbach's alpha was 0.93 in the present sample.

The Smartphone Addiction Scale–Short Version (Kwon et al., 2013) is a 10-item self-report measure originally designed to assess smartphone addiction symptoms in adolescents; initial validation showed high internal consistency (Cronbach's alpha = 0.91) and concurrent validity. Items were rated on a 6-point Likert scale from 1 (strongly disagree) to 6 (strongly agree). All items were scored in the same direction and summed to a total score of 10–60; in the present study, higher scores indicated greater severity of problematic smartphone use. The validated Persian version was developed through translation and back-translation and evaluated in 398 Iranian adolescents aged 12–18 years; confirmatory factor analysis supported a one-factor structure, and Cronbach's alpha was 0.82 (Fallahtafti et al., 2020). In the present sample, Cronbach's alpha was 0.88.

2.3. Data Analysis

Data screening and preliminary analyses were conducted using IBM SPSS Statistics, version 26. Questionnaire sets with missing responses on any primary-measure item or invalid response patterns were excluded before analysis. Means, standard deviations, and zero-order Pearson correlations were calculated from summed scale or subscale scores, whereas Cronbach's alpha coefficients were estimated from the corresponding items. All tests were two-tailed, with α set at .05.

Item-level CFA and SEM were conducted in R 4.6.0 with lavaan 0.6-21 (Rosseel, 2012). Models were estimated using weighted least squares mean- and variance-adjusted estimation (WLSMV) because the items were ordinal (Li, 2016). Separate CFAs were first fitted to each measure, followed by the full measurement model. The models specified three correlated Dark Triad factors, a general loneliness factor with two orthogonal method factors representing positive and negative item wording, and a single problematic smartphone use factor. Model fit was evaluated using the scaled chi-square statistic, comparative fit index (CFI), Tucker–Lewis index (TLI), root mean square error of approximation (RMSEA) with its 90% confidence interval, and standardized root mean square residual (SRMR). These indices were interpreted jointly; no single fixed cutoff served as the sole criterion for model acceptance (Chen et al., 2008). When initial fit was inadequate, residual

E-ISSN: 3041-8828

covariances were freed only with support from modification indices and plausible item-content overlap, a recognized source of correlated residuals in CFA (Bandalos, 2021). For the SAS-SV, six residual covariances were retained: items 1–2, 4–5, 5–6, 1–9, 1–10, and 9–10. Prior evidence partially supported residual correlations for items 1–2, 1–9, and 9–10 and content overlap for items 5–6 (Fallahtafti et al., 2020; Servidio et al., 2023). These pairs reflected functional interference (1–2), withdrawal or preoccupation (4–5 and 5–6), and impaired control or indicators of excessive use (1–9, 1–10, and 9–10). This specification was established in the separate SAS-SV CFA and retained in the full measurement and all structural models.

Following evaluation of the full measurement model, the hypothesized partial-mediation model specified paths from Machiavellianism, narcissism, and psychopathy to loneliness and PSU, and from loneliness to PSU. It was compared with a full-mediation model constraining all direct paths from the Dark Triad traits to PSU to zero and a restricted partial-mediation model omitting the direct psychopathy-to-PSU path. Nested models were compared using scaled chi-square difference tests appropriate for WLSMV. Unstandardized and standardized coefficients, standard errors, z statistics, p values, and explained variances (R^2) were reported. To retain the primary WLSMV analysis while obtaining nonparametric confidence intervals, 95% percentile bootstrap confidence intervals for indirect and total effects were obtained from an identically specified auxiliary model using diagonally weighted least squares (DWLS) with 5,000 resamples. Indirect effects were significant when their confidence intervals excluded zero. Given the cross-sectional design, direct and indirect effects were interpreted as statistical associations rather than causal effects.

3. Findings and Results

A total of 500 questionnaire sets were distributed to students who had voluntarily agreed to participate, and all were returned at the end of the administration session. Following data-quality screening, 21 questionnaire sets (4.2%) were excluded because they contained missing item responses on at least one of the three primary study measures or exhibited extended invariant or systematic repetitive response patterns suggestive of careless responding. This resulted in a final analytic sample of 479 participants. The sample comprised female students in Grades 10–12 from four selected regular public girls' upper-secondary schools in different districts of Tehran. Their mean age was 16.47 years (SD = 0.78; range = 15–18). The sample included 234 students in Grade 10 (48.9%), 193 in Grade 11 (40.3%), and 52 in Grade 12 (10.9%). Of these participants, 278 (58.0%) were enrolled in the mathematics and physics track, and 201 (42.0%) were enrolled in the experimental sciences track.

Descriptive statistics, Cronbach's alpha coefficients, and zero-order Pearson correlations are presented in Table 1. Cronbach's alpha coefficients ranged from 0.72 for psychopathy to 0.93 for loneliness. PSU was positively correlated with Machiavellianism (r = 0.36), narcissism (r = 0.38), psychopathy (r = 0.24), and loneliness (r = 0.26), all ps < 0.01. Machiavellianism and psychopathy were also positively correlated with loneliness (rs = 0.20 and 0.28, respectively), whereas the zero-order correlation between narcissism and loneliness was not significant (r = −0.01). The three Dark Triad traits were positively intercorrelated (rs = 0.15–0.43, all ps < 0.01).

Table 1

Descriptive statistics, Cronbach's alpha, and zero-order Pearson correlations

Variable	*M*	*SD*	α	1	2	3	4	5
1. Machiavellianism	7.36	3.41	0.83	-				
2. Narcissism	11.38	4.42	0.89	0.33**	-			
3. Psychopathy	8.59	3.56	0.72	0.43**	0.15**	-		
4. Loneliness	44.33	13.16	0.93	0.20**	−0.01	0.28**	-	
5. PSU	32.86	11.34	0.88	0.36**	0.38**	0.24**	0.26**	-

Note. N = 479. **p < 0.01.

Item-level confirmatory factor analyses were conducted using WLSMV for the ordered indicators. The three-factor Dirty Dozen model showed good fit, scaled $\chi^2(51) = 140.95$, $p < 0.001$, CFI = 0.987, TLI = 0.983, RMSEA = 0.061, and SRMR = 0.044. The UCLA Loneliness Scale model, which included a general loneliness factor and two orthogonal

E-ISSN: 3041-8828

wording-method factors, yielded scaled $\chi^2(150) = 682.95$, $p < 0.001$, CFI = 0.954, TLI = 0.942, RMSEA = 0.086, and SRMR = 0.055. Relative to the initial three-covariance SAS-SV specification, the three additional residual covariances corresponded to the largest remaining modification indices: items 5–6, MI = 56.22; items 1–10, MI = 31.28; and items 1–9, MI = 24.04. The resulting modified one-factor SAS-SV model yielded scaled $\chi^2(29) = 156.51$, $p < 0.001$, CFI = 0.974, TLI = 0.960, RMSEA = 0.096, and SRMR = 0.048 (Table 2). Although the CFI, TLI, and SRMR values were acceptable for the UCLA and SAS-SV models, their RMSEA values were elevated, particularly for the SAS-SV model. All standardized loadings were significant ($p < 0.001$). Loadings ranged from 0.704 to 0.895 for Machiavellianism, 0.781 to 0.892 for narcissism, 0.577 to 0.774 for psychopathy, 0.366 to 0.767 for negatively worded loneliness items, −0.863 to −0.417 for the unrecoded positively worded loneliness items, and 0.510 to 0.754 for the SAS-SV items. The resulting full measurement model of the five substantive constructs, which retained the six correlated SAS-SV residuals specified above, fit the data adequately, scaled $\chi^2(783) = 1548.11$, $p < 0.001$, CFI = 0.957, TLI = 0.953, RMSEA = 0.045, 90% CI [0.042, 0.049], and SRMR = 0.060.

Table 2

Fit indices for the measurement models

Measure	χ^2	*df*	CFI	TLI	RMSEA (90% CI)	SRMR
Dirty Dozen	140.95	51	0.987	0.983	0.061 [0.049, 0.073]	0.044
UCLA	682.95	150	0.954	0.942	0.086 [0.080, 0.093]	0.055
SAS-SV	156.51	29	0.974	0.960	0.096 [0.081, 0.111]	0.048

Note. The Dirty Dozen was specified as a three-factor model, UCLA as a general factor with two orthogonal method factors, and the SAS-SV as a one-factor model with six residual covariances. All χ^2 values are scaled, and all model χ^2 tests had $p < 0.001$.

The hypothesized partial mediation model showed acceptable fit, scaled $\chi^2(783) = 1548.11$, $p < 0.001$, CFI = 0.957, TLI = 0.953, RMSEA = 0.045, 90% CI [0.042, 0.049], and SRMR = 0.060. The model accounted for 15.4% of the variance in loneliness and 33.2% of the variance in PSU. A scaled χ^2 difference test showed that the full mediation model fit significantly worse than the partial mediation model, $\Delta\chi^2(3) = 155.45$, $p < 0.001$. By contrast, constraining the direct psychopathy-to-PSU path to zero did not significantly reduce model fit, $\Delta\chi^2(1) = 0.47$, $p = 0.494$. The prespecified partial mediation model was retained as the primary model, whereas the restricted partial mediation model provided an equivalently fitting, more parsimonious alternative (Table 3). A sensitivity analysis using the alternative SAS-SV specification with three residual covariances reproduced the direction and statistical significance of all structural paths, with a maximum absolute difference of 0.010 in the standardized coefficients.

Table 3

Fit indices for the alternative structural models

Model	χ^2	*df*	CFI	TLI	RMSEA (90% CI)	SRMR
Partial mediation	1548.11	783	0.957	0.953	0.045 [0.042, 0.049]	0.060
Full mediation	2580.20	786	0.900	0.891	0.069 [0.066, 0.072]	0.092
Restricted partial mediation	1541.81	784	0.958	0.954	0.045 [0.042, 0.048]	0.061

Note. The restricted partial-mediation model constrained the direct path from psychopathy to PSU to zero. All χ^2 values are scaled (all $p < 0.001$) and should not be differenced directly.

Among the paths to loneliness, psychopathy had a positive, significant association ($\beta = 0.324$, $p < 0.001$), narcissism had a negative, significant association ($\beta = -0.121$, $p = 0.025$), and the Machiavellianism path was not significant ($\beta = 0.124$, $p = 0.107$). Loneliness was positively associated with PSU ($\beta = 0.233$, $p < 0.001$). Machiavellianism ($\beta = 0.232$, $p = 0.001$) and narcissism ($\beta = 0.329$, $p < 0.001$) also had significant positive direct paths to PSU, whereas the direct path from psychopathy to PSU was not significant ($\beta = 0.045$, $p = 0.490$; Table 4 and Figure 1).

Percentile bootstrap confidence intervals were obtained from an identically specified auxiliary DWLS model with 5,000 resamples. The indirect effect of psychopathy on PSU through loneliness was positive and significant (b = 0.092, β

E-ISSN: 3041-8828

= 0.076, 95% bootstrap CI [0.037, 0.176], p = 0.002). The corresponding indirect effects of Machiavellianism (b = 0.035, β = 0.029, 95% bootstrap CI [−0.016, 0.096], p = 0.126) and narcissism (b = −0.035, β = −0.028, 95% bootstrap CI [−0.085, 0.000], p = 0.057) were not significant because their confidence intervals included zero. The total effects of Machiavellianism and narcissism on PSU were significant, whereas the total effect of psychopathy was not (Table 4).

Table 4

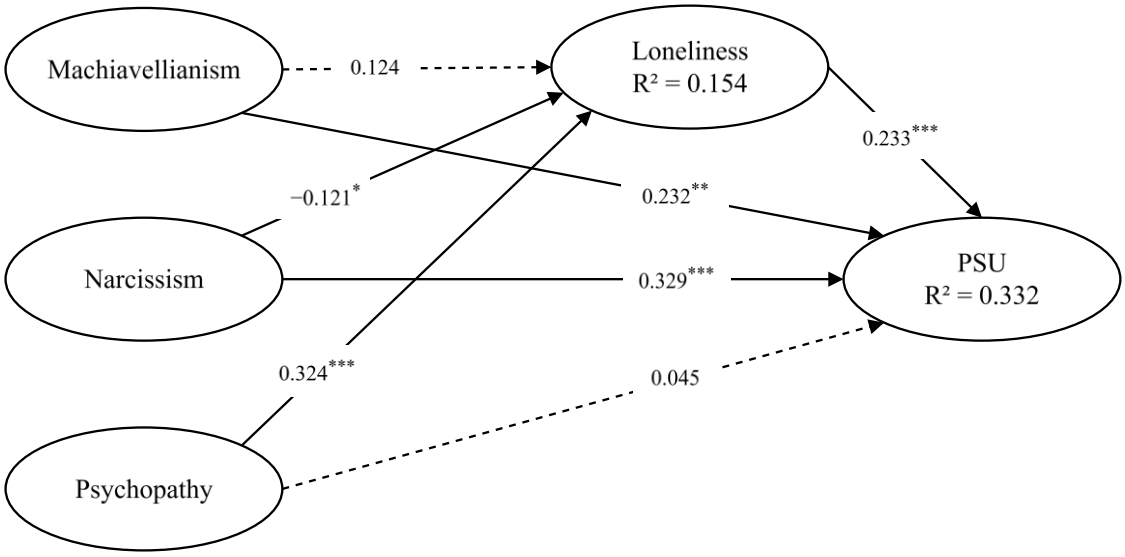
Direct, indirect, and total effects in the partial mediation model

Effect	b	SE	z	p	95% CI	β
Direct effects						
Machiavellianism → Loneliness	0.135	0.084	1.614	0.107	-	0.124
Narcissism → Loneliness	−0.132	0.059	−2.238	0.025	-	−0.121
Psychopathy → Loneliness	0.352	0.079	4.476	<0.001	-	0.324
Loneliness → PSU	0.262	0.058	4.506	<0.001	-	0.233
Machiavellianism → PSU	0.284	0.088	3.251	0.001	-	0.232
Narcissism → PSU	0.402	0.071	5.641	<0.001	-	0.329
Psychopathy → PSU	0.055	0.080	0.690	0.490	-	0.045
Indirect effects						
Machiavellianism → Loneliness → PSU	0.035	0.023	1.528	0.126	[−0.016, 0.096]	0.029
Narcissism → Loneliness → PSU	−0.035	0.018	−1.905	0.057	[−0.085, 0.000]	−0.028
Psychopathy → Loneliness → PSU	0.092	0.030	3.068	0.002	[0.037, 0.176]	0.076
Total effects						
Machiavellianism → PSU	0.320	0.088	3.631	<0.001	[0.133, 0.533]	0.261
Narcissism → PSU	0.368	0.069	5.353	<0.001	[0.219, 0.525]	0.300
Psychopathy → PSU	0.147	0.077	1.905	0.057	[−0.022, 0.328]	0.121

Note. All estimates and test statistics, except the 95% CIs, are from WLSMV. The percentile bootstrap CIs shown for the indirect and total effects were obtained from an identically specified DWLS model with 5,000 resamples. The unrounded upper CI for the indirect effect of narcissism via loneliness was 0.000262; therefore, the interval crossed zero.

Figure 1

Standardized path estimates for the partial mediation model



Note. Values are standardized path coefficients (β). R^2 indicates explained variance. Solid and dashed lines indicate statistically significant and nonsignificant paths, respectively. Covariances among the exogenous Dark Triad traits and all measurement components are omitted for clarity. *p < 0.05. **p < 0.01. ***p < 0.001.

E-ISSN: 3041-8828

4. Discussion and Conclusion

This study tested a model of direct and indirect associations between the three Dark Triad traits and PSU among adolescent girls, with loneliness specified as a statistical mediator. Although the proposed model fit the data acceptably, the results differed by trait. After shared variance among the traits was taken into account, psychopathy was positively associated with loneliness, narcissism was negatively associated with it, and Machiavellianism had no significant association. Significant positive direct associations with PSU were found for narcissism, loneliness, and Machiavellianism, with the largest coefficient for narcissism; psychopathy had no significant direct association. Only the indirect association between psychopathy and PSU through loneliness was significant. The total psychopathy–PSU association was nonsignificant. The indirect association through loneliness was therefore specific to psychopathy and was not shared by all three Dark Triad traits.

The three Dark Triad traits differed in their associations with loneliness. Psychopathy was positively associated with loneliness, consistent with findings in adolescents (Zhang et al., 2015), female and male university students (Sadeghzadeh et al., 2020), and young adults (Tomii & Oshio, 2024); null findings have also been reported (Özer, 2023). This result is compatible with the interpersonal callousness and low empathy characteristic of psychopathy (Zhang et al., 2015). Longitudinal evidence suggests a more complex temporal ordering in which loneliness may also precede later psychopathy (Pu & Gan, 2026). For narcissism, the unique association with loneliness was negative despite a negligible zero-order correlation. An adolescent study likewise reported a negligible bivariate estimate and a negative adjusted association (Zhang et al., 2015). Other studies have found no significant association (Çelikkaleli et al., 2022), positive associations for narcissistic facets such as shame, need for admiration, and distrust (Baerg MacDonald & Schermer, 2023), and a positive longitudinal association from loneliness to later narcissism (Pu & Gan, 2026). The present coefficient should therefore be interpreted as unique to narcissism after accounting for the other Dark Triad traits, not as evidence that narcissism generally protects against loneliness. Machiavellianism correlated positively with loneliness at the zero-order level, but its unique path was nonsignificant. Previous findings range from positive adjusted or prospective associations (Pu & Gan, 2026; Zhang et al., 2015) to attenuated or null direct associations (Çelikkaleli et al., 2022; Özer, 2023). These associations appear to vary by trait and remain sensitive to shared variance among the traits and analytic specification.

Direct associations with PSU differed across the three Dark Triad traits. Narcissism had the strongest positive direct association. Comparable positive associations remained in models that included fearful attachment and other dark traits (Balta et al., 2019), broader personality traits and impulsivity (Hidalgo-Fuentes, 2021), or FoMO (Servidio et al., 2021). Evidence for this pattern is not uniform, however. In another large sample, narcissism was essentially unrelated to PSU bivariately and had only a small adjusted association (Hussain et al., 2017). This variability may partly reflect heterogeneity within narcissism: grandiose narcissism was directly associated with compulsive smartphone use, whereas vulnerable narcissism was related indirectly through boredom (Ksinan et al., 2021). Machiavellianism was also positively and directly associated with PSU, consistent with an adjusted positive association after broader personality traits and impulsivity were controlled (Hidalgo-Fuentes, 2021). Its direct association was nonsignificant, however, in models including fearful attachment (Balta et al., 2019), FoMO (Servidio et al., 2021), or a wider set of personality characteristics (Giancola et al., 2026), suggesting sensitivity to model specification. For psychopathy, the positive zero-order correlation with PSU did not correspond to a significant unique path. Similar attenuation after adjustment has been reported when broader personality variables were considered (Giancola et al., 2026; Hidalgo-Fuentes, 2021); in a model including FoMO, the direct association was likewise nonsignificant (Servidio et al., 2021). Balta et al. (2019) observed a sign reversal after adjustment, which the authors regarded as a possible suppressor artifact and did not interpret substantively. The bivariate psychopathy–PSU association may therefore partly reflect variance shared with other personality characteristics rather than a distinct direct association.

Loneliness remained positively associated with PSU after accounting for the three Dark Triad traits. This finding aligns with meta-analytic evidence linking loneliness to smartphone or internet addiction in adolescents (Ge et al., 2025) and cross-sectional findings from high-school students assessed with the SAS-SV and UCLA Loneliness Scale (Erdem & Sezer Efe, 2022). A one-year longitudinal study further found that baseline loneliness predicted later smartphone addiction, whereas the reverse cross-lagged path

E-ISSN: 3041-8828

was nonsignificant; weekly diary data from the same study suggested that short-term fluctuations in the two constructs may be reciprocal (Hu & Xiang, 2024). Evidence is not uniform, however, as an inverse cross-sectional association was reported in a large high-school sample (Kürtüncü et al., 2021). Adolescents with unmet relational needs may increasingly turn to smartphones for connection or relief from distress, although the present cross-sectional design cannot establish the temporal direction of this association.

The indirect findings showed a distinct pattern for psychopathy, which was positively associated with PSU through loneliness; the corresponding indirect associations for Machiavellianism and narcissism were nonsignificant. This result should be interpreted narrowly because psychopathy's total association with PSU was not significant, and constraining its direct path to zero did not worsen model fit. It therefore indicates a path-specific indirect association rather than a general psychopathy–PSU association. More broadly, this pattern is cautiously consistent with the multiple-process logic of the I-PACE model. Within this model, person-related predispositions may be linked to problematic behaviors through different affective, cognitive, and control-related processes rather than a single uniform route (Brand et al., 2019). The superior fit of partial over full mediation further supports this interpretation because Machiavellianism and narcissism retained direct associations with PSU. Previous research has likewise examined other trait-specific statistical pathways between dark personality characteristics and PSU, including fearful attachment and fear of missing out (Balta et al., 2019; Servidio et al., 2021). Taken together, the findings favor pathways that differ across Dark Triad traits over a single loneliness-mediated mechanism. However, the cross-sectional data cannot establish the temporal or etiological processes proposed within I-PACE.

The findings have cautious implications for school-based assessment and prevention. Rather than treating adolescents with elevated PSU as a homogeneous group, school psychologists and counselors should consider interpersonal experiences, particularly loneliness, alongside broader personality-related differences when evaluating problematic smartphone use. The trait-specific pattern also suggests that loneliness should not be assumed to explain PSU uniformly across adolescents. In practice, attention to modifiable factors such as social connectedness, peer relationships, and smartphone-use patterns may be preferable to identifying or labeling students based on Dark Triad traits. School-based prevention could combine digital-use education with efforts to strengthen supportive peer relationships and identify students experiencing persistent loneliness. Given the cross-sectional design, however, these findings should guide assessment and hypothesis generation rather than justify specific interventions; prospective and experimental studies are needed to evaluate their effectiveness.

Several features strengthen the study. Simultaneously modeling all three Dark Triad traits allowed their unique associations with loneliness and PSU to be estimated while accounting for trait overlap. The analytic approach was further strengthened by item-level WLSMV analysis, prior evaluation of the measurement models, and bootstrap confidence intervals for indirect associations. Focusing on adolescent girls also addressed a comparatively understudied population.

These strengths should be considered alongside several limitations. First, the cross-sectional design precludes conclusions about temporal ordering or causality. Second, reliance on self-report measures may have introduced shared-method variance; the brief Dirty Dozen provides limited coverage of each Dark Triad trait, and objective device-recorded indicators of smartphone use were unavailable. Third, sample-size planning relied on a pragmatic participant-to-item ratio supplemented by general simulation evidence rather than a model-specific Monte Carlo power analysis, limiting precise evaluation of whether the final sample was adequate for all structural and indirect effects (Muthén & Muthén, 2002; Wolf et al., 2013). Fourth, convenience sampling from four public girls' upper-secondary schools in Tehran and inclusion only of students in the mathematics-physics and experimental sciences tracks limit the generalizability of the findings beyond this context, particularly to boys. Finally, the school-based sampling structure may have introduced dependence among observations that was not accounted for analytically, and clustering may therefore have affected the standard errors.

Future research should use longitudinal or intensive repeated-measure designs to clarify the temporal ordering of Dark Triad traits, loneliness, and PSU. Broader samples, including boys and students from different educational tracks and school settings, are needed to test generalizability. Studies should also account for clustering within classes and schools to obtain more precise estimates. Measurement could be strengthened through more comprehensive assessments of Dark Triad traits and by combining self-reported PSU with objective device-recorded indicators of smartphone use. Finally, because loneliness was a significant indirect correlate only for psychopathy, future

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studies should examine whether other affective, interpersonal, or self-regulatory processes better account for the associations of Machiavellianism and narcissism with PSU.

Overall, associations with PSU differed across the Dark Triad traits among adolescent girls. Direct associations were significant for Machiavellianism and narcissism; for psychopathy, the indirect association with PSU through loneliness was significant, whereas the direct association was not. Loneliness was independently associated with PSU, yet it did not function as a common indirect pathway across all three traits. The results are consistent with the possibility that personality-related and interpersonal factors relate to PSU through more than one process. Research on these relationships in adolescents should therefore consider trait-specific and interpersonal differences. Temporal, causal, and intervention-related conclusions require longitudinal and experimental evidence.

Authors' Contributions

All authors significantly contributed to this study.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

Acknowledgments

We hereby thank all individuals for participating and cooperating us in this study.

Declaration of Interest

The authors report no conflict of interest.

Funding

According to the authors, this article has no financial support.

Ethical Considerations

In this study, to observe ethical considerations, participants were informed about the goals and importance of the research before questionnaire administration and participated in the research with informed consent. The present study was approved by the Research Ethics Committee of Arak Branch, Islamic Azad University, Arak, Iran (Code: IR.IAU.ARAK.REC.1404.210).

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E-ISSN: 3041-8828