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RESEARCH ARTICLE



The mediational role of close teacher-student relationships in the link between loneliness and academic achievement: A longitudinal study in junior high school students

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ABSTRACT

Loneliness is a well-documented risk factor for adolescents' psychosocial and academic adjustment. However, the mechanisms through which loneliness is related to school performance remain unclear, as most prior studies have relied on cross-sectional designs. Drawing on the evolutionary theory of loneliness, this study tested whether teacher-student closeness (TSC) mediates the longitudinal association between loneliness and academic achievement (AA). Participants were 314 Italian junior high school students ($M_{age} = 12.28$, $SD_{age} = 0.83$; 51.9% female) assessed at two time points during the 2024–2025 academic year. Latent autoregressive cross-lagged panel models, controlling for sex, age, and cultural possessions, showed that loneliness at T1 predicted lower TSC at T2, whereas TSC at T1 predicted higher AA at T2. The direct effect of loneliness on AA was non-significant, but the indirect effect via TSC was significant. Findings suggest that loneliness may indirectly undermine academic achievement by weakening TSC.

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KEYWORDS

Loneliness; academic achievement; teacher-student closeness; autoregressive cross-lagged panel models; preadolescence

Introduction

Loneliness is a negative and unpleasant emotional state that arises from a discrepancy between the social relationships an individual actually experiences and those they desire, or from dissatisfaction with the quantity or quality of their social ties (Asher et al., 1984). Accordingly, loneliness can be broadly defined as a general sense of social dissatisfaction (Caputi et al., 2021). Although loneliness is typically assessed as a domain-general construct, its content is inherently relational: According to the content-specificity hypothesis of cognitive bias (Qualter et al., 2015), the cognitive and affective processes triggered by loneliness are not generic, but selectively target information related to one's primary concern (i.e. the quality of one's social relationships). Consequently, the cognitive consequences of loneliness can be expected to generalise across the different relational contexts in which adolescents are embedded, including their relationships with significant non-familial adults such as teachers.

Loneliness can be conceptualised as an adaptive signal that motivates individuals to strengthen their social bonds (Cacioppo & Hawkley, 2009; Maes & Vanhalst, 2025). However, alongside this adaptive function, loneliness can also trigger a state of social hypervigilance (Cacioppo et al., 2011), increasing sensitivity to potential interpersonal threats. While this heightened sensitivity can, in some cases, facilitate the restoration of bonds in perceived safe contexts (Qualter et al., 2015), it may also intensify negative evaluations of one's relationships and social skills, creating a vicious cycle that further compromises interaction quality (Cacioppo & Hawkley, 2009). Indeed, lonely individuals tend to report lower levels of support and trust (Bellucci, 2020; Spithoven et al., 2017) and are more likely to attribute hostile intentions to others in ambiguous situations, reinforcing expectations of social rejection (Qualter et al., 2013; Restrepo et al., 2025). These hypervigilance-related biases

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do not appear to be confined to a single relational target, but rather operate as a general lens through which lonely individuals interpret their social world (Restrepo et al., 2025); as such, they are also likely to shape how students perceive and evaluate the quality of their relationships with teachers. These mechanisms, which influence both the perception and quality of social relationships, are particularly relevant in the school context, one of the primary social environments for adolescents (Sundqvist et al., 2024). In this setting, students also have the opportunity to build meaningful relationships with non-familial reference adults, such as teachers, and these relationships can, in turn, influence their academic performance (Emslander et al., 2025).

However, the underlying mechanisms linking loneliness and school functioning are still largely unexplored. Research on the relation among loneliness, teacher-student relationships, and academic achievement has often relied on cross-sectional designs (Jefferson et al., 2023), limiting the ability to examine the temporal direction of effects and the processes underlying these associations. To address this gap, the present study investigated whether loneliness negatively predicts academic achievement in early adolescence over time via perceived teacher-student closeness (TSC), a key positive component of the more general construct of secure teacher-student relationships. Specifically, we hypothesised that loneliness and TSC would be negatively associated over time, and that TSC would emerge as the primary predictor of increased academic achievement, thereby serving as a longitudinal mediator of the link between loneliness and achievement. In the following section, we review existing literature on the interplay between loneliness, TSC, and academic achievement, and outline the rationale of our hypothesised effects.

Loneliness and teacher-student relationships

During early adolescence, the school context plays a fundamental role in shaping students' social and emotional well-being. Within this context, children and adolescents begin to form and navigate increasingly complex interpersonal relationships with significant others outside the family (Di Tata et al., 2025; Morinaj et al., 2023), which may contribute to broader evaluations of the adequacy and quality of their social relationships, and consequently to feelings of social satisfaction or dissatisfaction (Cacioppo & Hawkley, 2009). Hence, in the school environment, teachers play a central role, in particular by establishing positive teacher-student relationships. Teacher-student relationships (TSRs) 'refer to the quality of the relationship (s) between teaching personnel and their student(s) in schools' (Emslander et al., 2025, p. 366). According to literature, positive TSRs are characterised by high levels of teacher-student closeness (TSC), defined as 'the warmth of the interactions between teachers and students' (Emslander et al., 2025, p. 366). Although TSRs are inherently multidimensional, also encompassing conflict and dependency as relatively distinct dimensions (Sabol & Pianta, 2012; Zheng et al., 2024), the present study focuses specifically on closeness. This choice is grounded in evidence that these dimensions are differentially associated with student outcomes: while conflict has been more consistently linked to externalising behaviours and conduct problems, closeness appears to be the dimension most directly and consistently associated with academic achievement (Sundqvist et al., 2024). Given that academic achievement represents the distal outcome of interest in the present study, closeness constitutes the theoretically most relevant dimension of TSRs to examine.

Literature highlighted a bidirectional relationship between loneliness and the quality of TSRs. Positive TSRs provide students with a sense of belonging and emotional security that may mitigate feelings of loneliness (Zheng et al., 2024). A recent study conducted in a sample of children and early adolescents found a significant medium-sized negative cross-sectional correlation ($r = -.31$, $p < .01$) between close TSRs and loneliness (Di Tata et al., 2025). Conversely, conflictual or unsatisfying relationships with teachers may reduce students' sense of school connectedness and undermine affiliative needs, thereby increasing the risk of loneliness (Carney et al., 2020; Corso et al., 2013).

However, loneliness itself can negatively affect the development and maintenance of high-quality TSRs. Following Cacioppo's evolutionary theory, loneliness may trigger a state of social hypervigilance that heightens sensitivity to potential interpersonal threats and reinforces expectations of rejection (Cacioppo et al., 2011; Qualter et al., 2013). Such mechanisms often lead to more negative evaluations of one's relationships and social skills, reducing opportunities to establish trust and support, including with teachers (Qualter et al., 2013; Restrepo et al., 2025). In the school context, lonely students may withdraw socially and invest less effort in sustaining relationships with teachers, while teachers often lack adequate strategies to identify and address loneliness and thus struggle to provide sufficient emotional support (Stoeckli, 2009;

Verity et al., 2024). This dynamic fosters a vicious cycle in which loneliness contributes to deteriorating TSRs, which in turn exacerbates loneliness, with long-term implications for students' socio-emotional well-being and, ultimately, their academic achievement (Qualter et al., 2015; Zheng et al., 2024).

Teacher-student closeness and academic achievement

Research showed that positive TSRs promote learning outcomes. For example, Pianta et al. (2012) found that students with strong early relationships with teachers demonstrate better long-term academic and social outcomes. A meta-analysis by Roorda et al. (2017) reported that positive TSRs are associated with higher academic performance, particularly in primary and lower secondary school. More recently, a systematic second-order meta-analytic review conducted by Emslander et al. (2025) examined the association between TSRs and students' behaviour, cognitive and non-cognitive skills, and academic achievement. In this review, Emslander et al. (2025) found a significant meta-analytic weighted correlation between positive TSRs and academic performance (weighted- $r = .200$, 95%CI [.13, .27], $SE = .033$, $t = 6.03$, $p < .001$) across 12 meta-analyses.

Loneliness and academic achievement: the mediational role of teacher-student closeness

While the positive effects of good quality TSRs on adolescents' academic success are well established (Emslander et al., 2025), loneliness is likely to affect academic achievement indirectly, through different school- and individual-related mechanisms (Jefferson et al., 2023). However, these mediating mechanisms should be tested 'explicitly using prospective data' (Jefferson et al., 2023, p. 1010); nonetheless, there is a lack of longitudinal studies investigating the indirect relations between loneliness and academic outcomes. Given the reciprocal associations between loneliness and TSC, and considering that TSC appears to be a stronger predictor of academic achievement than loneliness, TSC represents a theoretically compelling mediating mechanism in the link between loneliness and academic achievement. In this view, loneliness may erode the perceived quality of TSC, which in turn is the key predictor of students' academic functioning.

The current study

Given the above empirical findings and theoretical considerations, this study aimed to test a longitudinal mediation model in which positive TSRs—operationalized as self-reported TSC levels—mediate the longitudinal association between loneliness and academic achievement. First, building on consolidated literature on the reciprocal negative relationship between loneliness and a decreased perception of the quality of relationships with significant others (Di Tata et al., 2025; Qualter et al., 2013; Restrepo et al., 2025), we hypothesised that:

H1: Loneliness at T1 negatively predicts TSC at T2.

H2: TSC at T1 negatively predicts loneliness at T2.

Second, given that there is strong evidence that perceived positive relationships with teachers support better academic outcomes (Emslander et al., 2025), we hypothesised that:

H3: TSC at T1 positively predicts academic achievement at T2.

Third, in line with previous hypotheses, loneliness is expected to reduce perceived TSRs quality, which in turn may negatively affect academic performance, suggesting a mediating mechanism played by perceived TSRs in the relation between loneliness and academic achievement. Therefore, we hypothesised that:

H4: Loneliness at T1 does not exert a significant longitudinal direct effect on academic achievement at T2.

H5: Loneliness at T1 indirectly affects academic achievement at T2 through TSC.

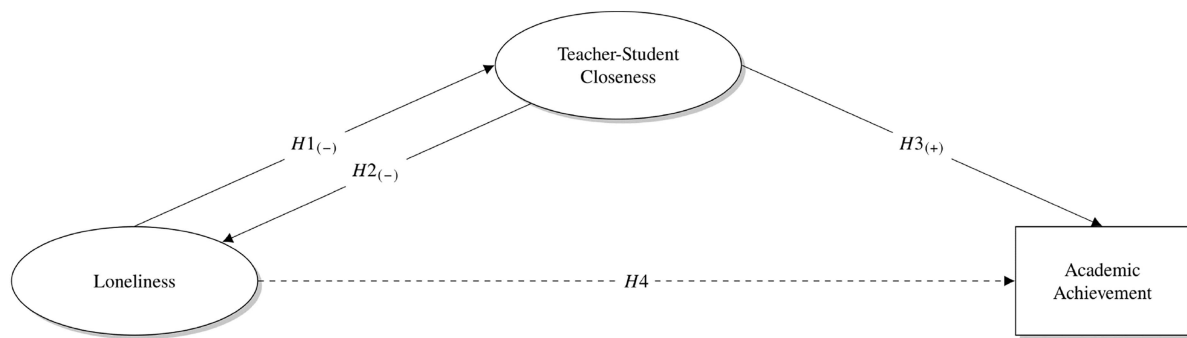


Figure 1. Hypothesised model. Note: Circles represent latent variables, while the rectangle represents an objective measure. Straight lines represent hypothesised significant paths, while dotted line represents the hypothesised non-significant direct effect. The sign in parentheses specifies the hypothesised direction of the path, with (+) indicating a positive association and (–) indicating a negative one.

In testing these hypotheses (see Figure 1), we adopted a latent-variable approach using a two-wave sample of junior high school students assessed at the end of the first semester (January 2025) and at the end of the second semester (June 2025) of the 2024–2025 school year. First, we established longitudinal measurement invariance for loneliness and TSC, thereby ensuring the structural validity of their measurement across time. Second, we estimated a series of competing cross-lagged autoregressive models, which allowed us to examine the hypothesised paths while accounting for the autoregressive effects of loneliness and teacher–student relationships. This half-longitudinal design further enabled the investigation of the proposed mediation mechanism (namely, the mediating role of TSC in the link between loneliness and academic achievement), whose significance was tested using a bootstrap approach (see Little, 2024, pp. 293–297). Finally, to increase the robustness of our findings, we controlled for several covariates that may influence these associations. In particular, we controlled for the effects of sex assigned at birth, cultural possessions, and age, given their documented associations with loneliness, teacher–student relationships, and academic achievement in previous research (e.g. Coplan et al., 2007; Heppt et al., 2022).

Method

Participants and procedure

The sample comprised 472 students recruited from eight junior high schools located in two different Italian regions. Only participants who completed the questionnaire at both time points (T1 and T2) were retained, resulting in a final sample of 314 students (for more details, see the paragraph ‘Attrition analysis and missing data consideration’). Participants’ age ranged from 11 to 14 years ($M = 12.28$, $SD = 0.83$). Regarding sex assigned at birth 163 (51.9%) were assigned female and 151 (48.1%) male. With respect to migratory background, 4.46% of students were born abroad, 74.8% had both parents born in Italy, 10.2% had one parent born abroad, and 5.41% had both parents born abroad (9.55% of data were missing on this variable). Students were nested within 81 classrooms. However, classroom sizes were highly unbalanced (range = 1–23 students; $M = 5.83$, Median = 5), with more than half of the classrooms including five or fewer students. Given the small and uneven cluster sizes, classroom membership was not modelled as a Level-2 nesting variable, and multilevel analyses were not performed. Instead, all analyses were conducted at the individual level.

Data were collected at two time points during the 2024–2025 school year. The first assessment (T1) took place in January 2025, and the second (T2) in June 2025. This time interval was chosen because it corresponds to the second half of the school year in Italy, allowing some students to become familiar with the school context. Before participation, informed parental consent and student assent were obtained. An instructional meeting to explain the objectives and the procedure of the study was conducted before the data collection with the school principals, teachers, and the students’ parents/guardians. Subsequently, students completed an online questionnaire administered via the Qualtrics platform.

The current study was part of a larger research project investigating the role of loneliness and psychosocial resources in the school context (see 'Funding' section). This research project received ethical approval from the ethical committees of Sapienza University of Rome (Protocol ID: CERT_1929B3BFD83) and University of Trento (Protocol ID: 2024-054).

Attrition analysis and missing data consideration

Participant attrition is a common pitfall in longitudinal research. In the present study, 158 participants (33.47%) dropped out at T2 (73 males and 85 females), resulting in a retention rate of 66.53% ($n = 314$). According to Little's MCAR test (Enders, 2022), the hypothesis that data were missing completely at random was rejected ($\chi^2 = 17.13$, $df = 2$, $p < .001$). Therefore, the missingness mechanism is unlikely to be completely random. Consequently, a series of Welch's t -tests were conducted to compare completers ($n = 314$) and dropouts ($n = 158$) on key study variables at T1. No significant difference emerged for loneliness between completers ($M = 1.93$, $SD = 1.02$) and dropouts ($M = 1.77$, $SD = 0.87$): $t = -1.82$, $df = 364.69$, $p = .069$, 95%CI $[-0.34, 0.01]$. Instead, a significant difference was found for teacher closeness with completers reporting higher teacher closeness ($M = 3.19$, $SD = 0.95$) compared to dropouts ($M = 2.89$, $SD = 0.83$): $t = -3.42$, $df = 355.57$, $p < .001$, 95%CI $[-0.46, -0.12]$. However, Cohen's d for this difference was small ($d = -0.32$), supporting the interpretation that differences between groups are small in practical terms.

Measures

Loneliness

Students' loneliness was measured using the shortened pure version (Rotenberg et al., 2004) of the *Loneliness and Social Dissatisfaction Questionnaire* (Asher et al., 1984; Caputi et al., 2021). Participants responded to four items¹ (e.g. 'I feel left out of things') rated on a 5-point Likert-type response scale ranging from 1 (*not at all true*) to 5 (*always true*). At T1, the alpha and omega reliability coefficients were .91 and .91, respectively, and at T2, they were .90 and .90, respectively.

Teacher-student closeness (TSC)

Students' perception of a close relationship with their main teacher was assessed using the Italian version of the *Student Perception of Affective Relationship with Teacher Scale* (SPARTS; Koomen & Jellesma, 2015; Longobardi et al., 2023). In this study, students evaluated only their relationship with their main classroom teacher. In the Italian school system, junior high school (*scuola secondaria di primo grado*) is compulsory, lasts three years, and is attended by students aged approximately 11–14 years. It is the first educational stage in which students are taught by subject-specific teachers within a common national curriculum. Students are assigned to fixed classes that typically remain stable throughout the three-year cycle. Each class has a 'main' teacher (usually the teacher of Italian, History, and Geography, who spends the greatest number of weekly hours with the class), who follows the same group of students across the entire cycle and serves as their primary adult reference at school. Consequently, students generally retain the same main teacher and classmates throughout junior high school, changing them only when transitioning to the next educational level (Longobardi et al., 2022). This relationship was assessed using the *Closeness* subscale of the SPARTS, which reflects openness, warmth, and security. The subscale consists of eight items (e.g. 'My teacher understands me') rated on a 5-point Likert-type response scale ranging from 1 ('*not at all true*') to 5 ('*completely true*'). At T1, the alpha and omega reliability coefficients were .88 and .88, respectively, and at T2 they were .89 and .90, respectively.

Academic achievement (AA)

Students' academic achievement data were obtained from school records, which provided end-of-year grades (T2). In this study, we used grades from three core subjects: Mathematics, Science, and Italian (verbal achievement). These subjects are widely employed in international assessments (e.g. OECD's Programme for International Student Assessment survey). At T2, the alpha and omega reliability coefficients were .90 and .91, respectively. In the structural equation models, academic achievement was modelled as a latent variable, with Mathematics, Science, and Italian grades serving as observed indicators.

Covariates

Sex and age

Sex assigned at birth was coded as 1 = *female* and 0 = *male*. Participants were asked, 'What is your sex assigned at birth?' to assess sex. Age was assessed by asking, 'Please indicate your age'.

Cultural possessions (CP)

Family Cultural Possessions (CP) were assessed by asking students the following question: 'About how many books are there in your home (excluding school books)?' Responses were provided on a 5-point Likert-type response scale: (1) *None or very few (0–10 books)*, (2) *Enough to fill one shelf (11–25 books)*, (3) *Enough to fill one bookcase (26–100 books)*, (4) *Enough to fill two bookcases (101–200 books)*, and (5) *Enough to fill three or more bookcases (more than 200 books)*. Illustrations were provided to facilitate answering this item. This 1-item measure captures only one dimension of Cultural Capital, namely the *objectified cultural resources in the household* (Sieben & Lechner, 2019). However, it is widely used as an extension of SES (Evans et al., 2010), and it showed incremental validity in explaining academic achievement over traditional measures of SES (parental occupation, parental education) (Heppt et al., 2022).

Data analytic plan

Measurement invariance and ACLP models

The hypothesised theoretical model was tested using a two-wave latent variable autoregressive cross-lagged panel model (ACLPM; Little, 2024). In two-wave models, the indirect effect is estimated as the product of two cross-lagged paths: (a) from the independent variable at Time 1 (Loneliness) to the mediator at Time 2 (Teacher–Student Closeness), and (b) from the mediator at Time 1 to the dependent variable at Time 2 (Academic Achievement).

All pre-processing steps (i.e. data cleaning and data management procedures, including merging data from different sources, reverse-coding items, computing reliability indices, and generating descriptive statistics) and Structural Equation Models (SEMs) were performed in the open-source statistical software R (Version 4.5.1). SEMs were estimated with the R package lavaan (Version 0.6-21; Rosseel, 2012) using Maximum Likelihood with Robust standard errors (MLR).

In the first step, longitudinal measurement invariance for loneliness and teacher-student closeness (measured with their respective items) was tested through a series of competing models: Configural (same factorial structure across time), metric (factor loadings constrained equal), and scalar (factor loadings and intercepts constrained equal).

In the second step of the analysis, we estimated a series of two-wave ACLP models to examine the hypothesised mediation. The variables included loneliness and teacher-student closeness at T1 and T2, while academic achievement was measured only at T2. Models were estimated using Full Information Maximum Likelihood (FIML) to handle missing data (Enders, 2022). In all ACLP models, residual covariances between corresponding items at T1 and T2 were specified for both Loneliness and Teacher–Student Closeness, and an additional residual covariance was specified between two conceptually overlapping Teacher–Student Closeness items (item 3 and item 4) at both time points. The latent factors of Loneliness and Teacher–Student Closeness were allowed to correlate both at T1 (exogenous covariance) and at T2 (endogenous, residual, covariance). We tested 4 ACLP models.

First, a fully unconstrained model (M1) was estimated, with all paths freely estimated to serve as a baseline for subsequent comparisons. In model 2 (M2), the path from loneliness at T1 to academic achievement at T2 was fixed to zero to test whether this effect could be omitted without worsening model fit. In model 3 (M3), the path from teacher-student closeness at T1 to loneliness at T2 was also constrained to zero, in order to examine the robustness of the hypothesised cross-lagged relationships and potential mediation pathways. Finally, in model 4 (M4) we included sex, age, and cultural possession as covariates to control for potential confounding factors. In more detail, sex, age, and cultural possessions were specified as predictors of all three T2 endogenous latent variables.

Model evaluation

Model fit was evaluated using the Yuan-Bentler χ^2 statistic ($YB\chi^2$), Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and Standardised Root Mean Square Residual (SRMR). Values of CFI and TLI above 0.90, RMSEA below 0.06, and SRMR below 0.08 were considered indicative of adequate fit (Kline, 2023). Nested models were compared as follows: For measurement invariance, we used the Satorra-Bentler scaled difference test ($\Delta SB\chi^2$; Satorra & Bentler, 2001) and changes in CFI (ΔCFI), considering non-significant $\Delta SB\chi^2$ and $\Delta CFI < .01$ as evidence of invariance (see Little, 2024, p. 190). For competing ACLP models, we relied solely on the $\Delta SB\chi^2$.

The statistical significance of indirect effects was assessed using bootstrap resampling with 1000 replications. An indirect effect was considered significant if the 95% bias-corrected confidence interval did not include zero.

The code and data necessary to replicate the analyses are available on the following GitHub repository https://github.com/SimoneZasso/Loneliness_TSC_AA.

Results

Zero-order correlations

Descriptive statistics for all study variables and zero-order correlations for the composite scores of study variables (obtained by averaging their respective items/indicators; the full correlation matrix is reported in the online repository) are reported in Table 1 and Table 2, respectively. Loneliness at T1 was negatively correlated with Teacher–Student Closeness at T2 ($r = -0.32, p < .01$). Teacher–Student Closeness at T1 was negatively correlated with Loneliness at T2 ($r = -0.32, p < .01$) and positively correlated with Academic Achievement at T2 ($r = 0.27, p < .01$). Loneliness at T1 and Teacher–Student Closeness at T1 also showed

Table 1. Descriptive statistics.

Variable	<i>n</i>	<i>M</i>	<i>SD</i>	median	min	max	skew	kurtosis
Age	314	12.28	0.83	12	11	14	0	−0.75
Cultural Possessions T1	313	2.91	1.17	3	1	5	0.19	−0.66
Loneliness i1 T1	314	2.14	1.22	2	1	5	0.64	−0.76
Loneliness i2 T1	314	2.1	1.18	2	1	5	0.72	−0.49
Loneliness i3 T1	314	1.9	1.16	1	1	5	1.11	0.2
Loneliness i4 T1	314	1.59	1.02	1	1	5	1.77	2.26
Loneliness T1 (Comp Score)	314	1.93	1.02	1.5	1	5	0.95	−0.09
Loneliness i1 T2	314	2.07	1.14	2	1	5	0.58	−0.94
Loneliness i2 T2	314	2.06	1.13	2	1	5	0.78	−0.37
Loneliness i3 T2	314	1.84	1.06	1	1	5	1.06	0.16
Loneliness i4 T2	313	1.61	1.03	1	1	5	1.75	2.35
Loneliness T2 (Comp Score)	314	1.89	0.96	1.5	1	4.75	0.88	−0.29
TSC i1 T1	314	3.87	1.1	4	1	5	−0.8	0.02
TSC i2 T1	313	3.63	1.37	4	1	5	−0.57	−0.96
TSC i3 T1	314	2.02	1.26	2	1	5	1.02	−0.09
TSC i4 T1	314	2.43	1.28	2	1	5	0.42	−0.91
TSC i5 T1	314	3.48	1.26	4	1	5	−0.51	−0.69
TSC i6 T1	314	4.03	1.18	4	1	5	−1.14	0.46
TSC i7 T1	314	3.24	1.47	3	1	5	−0.19	−1.33
TSC i8 T1	314	2.79	1.31	3	1	5	0.07	−1.1
TSC T1 (Comp Score)	314	3.19	0.95	3.25	1	5	−0.28	−0.54
TSC i1 T2	314	3.91	1.11	4	1	5	−0.91	0.17
TSC i2 T2	314	3.5	1.36	4	1	5	−0.5	−0.94
TSC i3 T2	313	2.1	1.21	2	1	5	0.85	−0.29
TSC i4 T2	314	2.45	1.26	2	1	5	0.46	−0.84
TSC i5 T2	313	3.44	1.25	4	1	5	−0.46	−0.67
TSC i6 T2	312	4.03	1.13	4	1	5	−1.12	0.5
TSC i7 T2	314	3.1	1.38	3	1	5	−0.05	−1.19
TSC i8 T2	314	2.86	1.26	3	1	5	0.01	−0.98
TSC T2 (Comp Score)	314	3.17	0.95	3.25	1	5	−0.23	−0.57
Math T2	314	7.92	1.59	8	4	10	−0.19	−1.13
Verbal T2	314	8.2	1.18	8	5	10	−0.1	−0.84
Science T2	314	8.33	1.31	8	4	10	−0.39	−0.63
Academic Achievement T2 (Comp Score)	314	8.15	1.26	8.33	5	10	−0.21	−0.92

Note: TSC = Teacher–Student Closeness. i = item. Comp Score = Composite Score (average of items for Loneliness and TSC; average of observed indicators for Academic Achievement).

Table 2. Zero-order correlations.

Variable	1	2	3	4	5	6	7
1. Age							
2. Sex	.04						
3. Cultural Possessions T1	-.11	-.08					
4. Loneliness T1	.17**	.21**	-.13*				
5. Loneliness T2	.17**	.22**	-.12*	.76**			
6. TSC T1	-.26**	-.04	.22**	-.27**	-.23**		
7. TSC T2	-.24**	-.00	.18**	-.32**	-.28**	.78**	
8. Academic Achievement T2	-.06	.09	.29**	-.05	-.07	.23**	.27**

Note: TSC = Teacher–Student Closeness. * $p < .05$. ** $p < .01$. *** $p < .001$.

Table 3. Longitudinal measurement invariance of latent variables at the two time points (T1, T2).

Variable	Model	YBX ²	df	p	SCF	R-CFI	R-TLI	R-RMSEA	SRMR	ΔSBX ²	Δdf	p	ΔCFI
Lon	Configural	23.877	15	.067	1.345	.994	.989	.05	.02	–	–	–	–
	Metric	26.367	18	.092	1.295	.995	.992	.044	.026	1.949	3	.583	<.001
	Scalar	28.711	21	.121	1.251	.995	.994	.038	.027	1.793	3	.617	<.001
TSC	Configural	239.678	93	<.001	1.084	.946	.931	.074	.047	–	–	–	–
	Metric	246.988	100	<.001	1.067	.947	.937	.071	.050	4.379	7	.735	<.001
	Scalar	261.546	107	<.001	1.062	.945	.938	.070	.051	14.39	7	.045	.002

Note: Lon = Loneliness; TSC = Teacher–Student Closeness; YBX² = Yuan–Bentler scaled chi-square statistic; df = Degrees of freedom; SCF = Scaling Correction Factor; R-CFI = Robust Comparative Fit Index; R-TLI = Robust Tucker–Lewis Index; R-RMSEA = Robust Root Mean Square Error of Approximation; SRMR = Standardised Root Mean Square Residual; ΔSBX² = Satorra–Bentler scaled difference test; Δdf = Difference in degrees of freedom; ΔCFI = Difference in CFI.

Table 4. Results of competing Autoregressive Cross-Lagged Panel Models.

Model	NFP	YBX ²	df	p	SCF	R-CFI	R-TLI	R-RMSEA	SRMR	ΔSBX ²	Δdf	p
M1	105	523.289	310	<.001	1.053	.962	.957	.048	.046	–	–	–
M2	104	523.419	311	<.001	1.054	.962	.957	.048	.046	0.164	1	.686
M3	103	523.382	312	<.001	1.054	.962	.958	.047	.046	0.032	1	.858
M4	112	675.893	384	<.001	1.040	.950	.943	.050	.069	–	–	–

Note: NFP = Number of Free Parameters; YBX² = Yuan–Bentler scaled chi-square statistic; df = degrees of freedom; SCF = Scaling Correction Factor; R-CFI = Robust Comparative Fit Index; R-TLI = Robust Tucker–Lewis Index; R-RMSEA = Robust Root Mean Square Error of Approximation; SRMR = Standardised Root Mean Square Residual; ΔSBX² = Satorra–Bentler scaled difference test; Δdf = Difference in degrees of freedom; M1 = Unconstrained model; M2 = M1 with the effect of Loneliness T1 to Academic Achievement T2 fixed to zero; M3 = M2 with the effect of Teacher–Student Relationship T1 to Loneliness T2 fixed to be zero; M4 = M3 by adding covariates (therefore M4 and M3 are not comparable because of different variance/covariance matrix).

strong stability over time, being positively correlated with their respective T2 measures (Loneliness: $r = 0.76$, $p < .01$; Teacher–Student Closeness: $r = 0.78$, $p < .01$).

Measurement invariance

Measurement invariance across time was tested for Loneliness and Teacher–Student Closeness. Results are reported in Table 3. Goodness-of-fit indices (ΔSBX², ΔCFI) indicated that all configural models fit the data well. For Loneliness, both metric (equal factor loadings) and scalar (equal intercepts) invariance were supported, with ΔSBX² and ΔCFI values showing no meaningful worsening of fit. Similarly, for Teacher–Student Closeness, metric invariance was fully supported, while scalar invariance showed a significant ΔSBX² but acceptable changes for ΔCFI (< 0.01).

ACLP models and mediation analysis

After establishing invariance, we tested a series of competing ACLP models. Results are reported in Table 4. As shown, Model 1 (M1) displayed an adequate fit to the data according to established criteria. Model 2 (M2) did not significantly worsen M1 after constraining the path from Loneliness T1 to Academic Achievement T2 to zero, suggesting that Loneliness did not exert a direct longitudinal effect on Academic Achievement. Similarly, Model 3 (M3) did not significantly worsen M2 after constraining the path from Teacher–Student Closeness T1 to Loneliness T2 to zero. In Model 4 (M4), we included covariates to control for potential confounding effects; the model continued to fit the data well.

Standardised estimates are reported in Figure 2. Standardised autoregressive paths indicated strong stability over time for both Loneliness ($\beta = .79, p < .001$) and Teacher–Student Closeness ($\beta = .80, p < .001$). The effect of Loneliness T1 on Teacher–Student Closeness T2 was negative and significant ($B = -0.091, \beta = -.125, z = -2.734, p = .006$), thereby supporting H1. The effect of Teacher–Student Closeness T1 on Loneliness T2 could be fixed to zero (according to M3), thereby not supporting H2. The effect of Teacher–Student Closeness T1 on Academic Achievement T2 was positive and significant ($B = 0.381, \beta = .212, z = 3.357, p = .001$), supporting H3. The effect of Loneliness T1 on Academic Achievement T2 could be fixed to zero (according to M2), thus supporting H4. Finally, to further test the significance of the indirect effect predicted in H5, bootstrap analyses showed that the 95% bias-corrected confidence interval of the indirect estimate did not include zero (estimate = -0.034 , 95%CI [$-0.067, -0.002$]), supporting the significance of the indirect effect.

Discussion

The present study examined the hypothesised longitudinal mediating role of positive TSRs (operationalized through the dimension of teacher–student closeness; TSC) in the link between loneliness and academic achievement in early adolescence. Using a sample of early adolescents in Italy attending junior high school and assessed at two time points, we extended previous research that has largely relied on cross-sectional designs (Zheng et al., 2024) by employing a two-wave autoregressive cross-lagged model to test the directional associations among loneliness, TSC, and academic achievement. In line with previous literature identifying loneliness as capable of reducing the positive perception of one’s own relationships (Cacioppo et al., 2011; Qualter et al., 2013) and TSC as an important factor able to positively influence academic performance (Emslander et al., 2025), our findings indicated that loneliness longitudinally predicted decreases in adolescents’ perceived closeness with teachers, and in turn, higher levels of TSC were

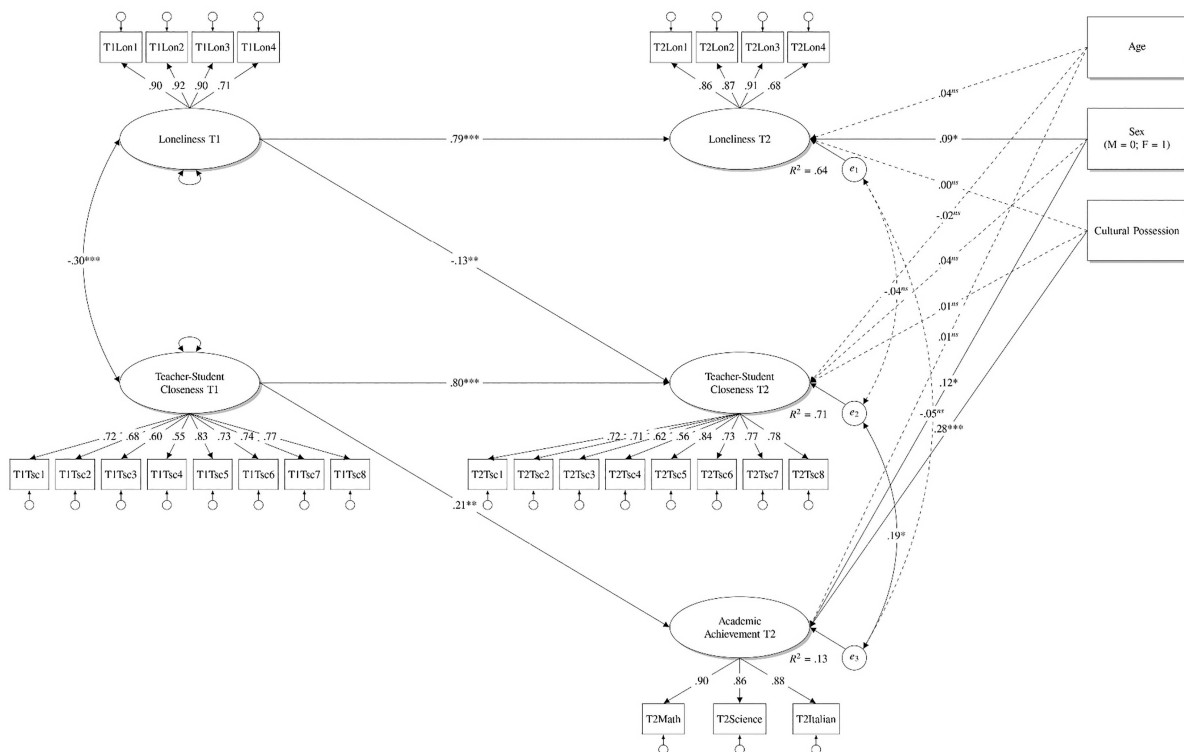


Figure 2. Model 4. Note: Residual covariances between (a) the same items across time points and (b) Items 3 and 4 of the Teacher–Student Closeness scale were included in the model but are omitted from the figure for clarity. Metric invariance is imposed for Loneliness and Teacher–Student Closeness. Straight and dotted lines represent significant and non-significant paths, respectively. n.s. = $p > .05$. * $p < .05$, ** $p < .01$, *** $p < .001$. All factor loadings had $p < .001$.

longitudinally associated with better academic outcomes. In other words, loneliness undermined students' perceived support from teachers over time, and TSC served as a pathway through which loneliness only indirectly influenced academic performance. This interpretation aligns with the evolutionary theory of loneliness, which frames loneliness both as a motivational signal to restore social connections and as a risk factor for hypervigilance and negative biases in social interactions (Cacioppo & Hawkley, 2009; Spithoven et al., 2017).

Moreover, the results confirmed all our initial hypotheses, with the only exception of Hypothesis 2, which stated that TSC would influence loneliness over time. In fact, we did not find any effect in this direction, despite previous literature supporting the bidirectionality of these associations (Zheng et al., 2024). One possible explanation for this non-significant path is that our measure of TSC relied exclusively on students' perceptions, whereas we did not include teachers' perspectives, which might have provided a more comprehensive assessment of classroom climate. Beyond this measurement-related explanation, it is important to note that the existing literature on this bidirectionality remains controversial. Indeed, in the meta-analysis cited above (Zheng et al., 2024), the longitudinal effect of loneliness on TSRs quality ($\beta = -.1661$, $SE = 0.0903$, 95%CI [.3431, .0109], $p = 0.0659$) showed a higher but more unstable estimate than the longitudinal effect of TSRs quality on loneliness ($\beta = -.0917$, $SE = 0.0127$, 95%CI [0.1165, 0.0668], $p < 0.0001$). This is probably due to the small number of studies ($k = 5$ and 6, respectively). Therefore, evidence for this bidirectional association remains inconclusive, and our study contributes an additional longitudinal test of these relationships. From a theoretical perspective, another possible explanation is that the pattern we observed aligns with evidence suggesting that negative interpersonal experiences exert a stronger and more generalisable influence on relationship perceptions than positive experiences exert in reducing negative affect (Baumeister et al., 2001). This asymmetry may help explain why loneliness predicted subsequent TSC more robustly than TSC predicted subsequent loneliness. Nevertheless, future research is needed to determine the contextual and developmental conditions under which this pattern, or the reverse pattern, is more likely to occur.

Limitations and future directions

This study has several strengths, including the use of a longitudinal design, the combination of self-report and objective academic achievement data, and the application of a rigorous latent-variable approach. Nonetheless, several limitations should be acknowledged.

First, the longitudinal design was restricted to two time points, which limited the possibility of examining within-person dynamics. Future studies with at least three measurement occasions may simultaneously test a full longitudinal mediation model (in which the indirect effect is estimated through the path from the predictor at T1 to the mediator at T2 and from the mediator at T2 to the outcome at T3) and a random-intercept cross-lagged panel model (RI-CLPM), which disentangles stable between-person differences from within-person processes. This would provide a more rigorous test of the links between loneliness, teacher-student closeness, and academic achievement. Nevertheless, the two-wave design adopted in the present study still allowed us to estimate a half-longitudinal mediation model, which represents a stronger test of mediation than a cross-sectional design because it incorporates temporal ordering and controls for the stability of the focal constructs (Little, 2024).

Second, the study adopted a specific time lag (approximately four months) between assessments. Although this interval was suitable for examining developmental processes across one school term, different time lags may produce different results (Dormann & Griffin, 2015).

Third, the generalisability of the findings is limited. The sample consisted of junior high school students in Italy, and cultural or contextual factors may have influenced both the experience of loneliness and the nature of teacher-student relationships. Furthermore, attrition analyses revealed that students who dropped out reported significantly lower levels of teacher-student closeness at T1 than those who remained in the study, although the effect size was small. This pattern suggests that students who perceive less supportive relationships with teachers may be less likely to participate in follow-up assessments. Consequently, the final sample may slightly overrepresent adolescents experiencing more positive teacher-student relationships, potentially limiting the generalisability of the findings. Future research

should further investigate the factors associated with participant retention and examine whether school engagement, trust in adults, or perceived support contribute to longitudinal participation.

Fourth, we used only academic achievement measures assessed at T2. Given the relatively short interval between assessments, academic achievement would be expected to show substantial rank-order stability over time, limiting the extent to which meaningful changes in performance could be observed (Dormann & Griffin, 2015). Nevertheless, the absence of a baseline measure prevented us from modelling the autoregressive effect of academic achievement. Future studies adopting longer time spans between assessments should include academic achievement at multiple time points to better examine changes in academic performance and their associations with loneliness and teacher–student relationships.

Fifth, the indirect effect was small, as indicated by the upper bound of the 95% confidence interval being close to zero. Although small indirect effects are common in longitudinal mediation analyses—given that cross-lagged effects are typically weaker than associations observed in cross-sectional designs (Orth et al., 2024)—the magnitude of the effect warrants caution. Therefore, although the mediation hypothesis was supported, the results should be interpreted cautiously and replicated in future studies using different samples and research designs.

Practical implications

This study is the first to longitudinally demonstrate that positive TSRs function as a mediating mechanism linking loneliness to academic achievement. From a theoretical standpoint, our findings extend the evolutionary model of loneliness by showing that processes such as hypervigilance and negative expectations can also shape students' (perceived) relationships with teachers (Cacioppo & Hawkley, 2009). From an applied perspective, the results suggest that fostering positive teacher–student relationships may represent a key pathway through which the detrimental effects of loneliness on students' academic performance can be mitigated. In practice, teachers may be supported in recognising students at risk of low TSC through observable cues, such as exclusion during group work or sudden changes in participation (Zheng et al., 2026). Concrete strategies to strengthen TSC may include adjusting seating and group compositions to foster natural inclusion, and embedding social-emotional learning into everyday teaching. Even brief relational practices may help: A short-term intervention based on daily individual conversations between teachers and students significantly improved teacher-reported closeness, without a comparable effect on conflict (Martinez et al., 2025). Equipping teachers with such observational and relational skills, for instance through dedicated training, may represent a feasible avenue for translating the present findings into school practice.

Conclusion

The findings of this study suggest that teacher–student closeness may represent an important relational mechanism linking loneliness to academic achievement in early adolescence. Specifically, loneliness did not directly predict subsequent academic achievement; rather, its association with achievement operated indirectly through lower levels of perceived teacher–student closeness. From a theoretical perspective, these findings extend the evolutionary theory of loneliness (Cacioppo & Hawkley, 2009) by suggesting that the social hypervigilance and negative interpersonal expectations associated with loneliness may generalise beyond peer relationships and influence adolescents' perceptions of relationships with significant non-familial adults, such as teachers. At the same time, alternative explanations should be considered. For example, unmeasured factors such as broader school engagement, social competence, or classroom climate may contribute both to the quality of teacher–student relationships and to academic success. Nevertheless, our findings highlight the potential protective role of close teacher–student relationships in the school context. From an applied perspective, interventions aimed at reducing loneliness and fostering supportive teacher–student interactions may help promote both students' socio-emotional adjustment and academic achievement (Emslander et al., 2025; Qualter et al., 2015).

Endnote

1. The original reduced scale encompassed five items. However, one item ('*There is no one I can turn to when I need help*') was excluded for several reasons. First, it showed the lowest corrected item–total correlation ($r = .59$ vs. $.73$ – $.81$ for the remaining items). Second, a longitudinal CFA including this item yielded substantially poorer fit (Robust CFI = $.94$, Robust TLI = $.91$, Robust RMSEA = $.13$) than the four-item solution (Robust CFI = $.99$, Robust TLI = $.99$, Robust RMSEA = $.05$). Moreover, the item exhibited relatively low factor loadings at both T1 ($\lambda = .55$) and T2 ($\lambda = .62$), compared with the loadings observed in the four-item solution ($\lambda = .71$ – $.91$), and showed a significant residual covariance with one item ('*I have no one to talk to*'). Third, from a conceptual standpoint, the item reflects perceived availability of support rather than the subjective experience of social dissatisfaction that lies at the core of loneliness as conceptualised in the present study (Asher et al., 1984; Caputi et al., 2021). For all these reasons, we decided to remove this item.

Author contributions

SZ: Investigation, Conceptualisation, Methodology, Writing – original draft, Formal analysis; GG: Investigation and Writing – original draft; LD: Investigation and Writing – review & editing; LM: Investigation and Writing – review & editing; GS: Investigation and Writing – review & editing; SS: Conceptualisation, Funding acquisition, Project administration, Writing – original draft, Writing – review & editing, Supervision; EP: Conceptualisation, Funding acquisition, Project administration, Writing – original draft, Writing – review & editing, Supervision. All authors read and approved the final manuscript.

Disclosure statement

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Data availability statement

The code and data necessary to replicate the analyses are available on the following GitHub repository link https://github.com/SimoneZasso/Loneliness_TSC_AA.

Ethical approval and informed consent

The study protocol was approved by the privacy office of University of Trento, and by the ethics committees of the University of Trento (Protocol ID: 2024-054) and Sapienza University of Rome (Protocol ID: CERT_1929B3BFD83).

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