

A multisystemic perspective on the temporal interplay between adolescent depression and resilience-supporting individual and social resources

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Highlights

- Resources show time- and symptom-dependent effects for adolescent depression.
- Physical functioning protects against somatic symptoms in the short-term.
- Social support protects against cognitive-affective symptoms in the short-term.
- Multiple resources heighten resilience to depression in general in the long-term.

Abstract

Background: Adolescent depression can severely interfere with age-appropriate and lifetime development and functionality. Physical functioning in daily life (as a means of individual support) as well as social support from family and friends have been shown to enhance adolescent resilience against depression. By applying a multisystemic model of resilience, this study investigates how these resources reciprocally influence each other and how they interact with depression over time.

Methods: Longitudinal data (three assessments over three years) from the Resilient Youth in Stressed Environments project was analyzed using panel network analysis to investigate short- and long-term uni- and bidirectional effects. The sample consisted of $N = 500$ adolescents from Canada (mean age = 18.49, $SD = 3.01$, 56.40% young women) at the first assessment.

Results: Depression seemed to fluctuate, while the resources showed significant stability over the course of the study. Perceived family and friend support were not significantly influenced by depression while they had significantly negative temporal effects on depression. Only physical functioning showed a negative feedback loop, notably with somatic symptoms of depression. Family and friend support shared a reinforcing feedback loop, while physical functioning was not related to either type of support.

Limitations: Future studies should address the low average of depressive symptomatology and subjective, global measures of social support.

Conclusions: The resources show potential time-dependent effects: symptom-specific resources need to be applied in the short-term, while a pool of multisystemic resilience resources seems necessary over the long-term to increase the resilience to depression among adolescents.

Keywords: Multisystemic resilience; Network analysis; Longitudinal; Depression; Adolescence

Depression has become the leading diagnosis of psychopathology during adolescence over the past decades (Jane Costello et al., 2006; Kessler et al., 2005; Twenge et al., 2019). This increase has raised interest in the resources which support the resilience of adolescents against depression. From an outcome perspective, an individual can be considered resilient if the person shows positive development, mental health, and adaptive functioning in the context of significant adversity (Kalisch, 2017). This outcome definition relies on a processual definition of resilience in which a person can be resilient if contextually meaningful resources are available and accessible (Ungar, 2008). Physical functioning and activity in daily life as a means of individual support (Oberste et al., 2020) as well as social support (Rueger et al., 2016; Thapar et al., 2012) have repeatedly been found to be examples of contextually meaningful resources that foster resilience where depression reduces an adolescent's ability to function optimally. Traditionally, different sources of social support such as friends, peers, teachers, or family members have been researched for their independent effects on depression (Garipey et al., 2016; Rueger et al., 2016). However, recent developments in the theory of multisystemic resilience and related empirical studies show that resources can be mutually dependent within and across different resource systems (Fritz et al., 2018; Höltege et al., 2020; Ungar and Theron, 2020), with developmental and behavioral outcomes explained best by accounting for within system and cross-scale interactions over time. Therefore, while physical functioning and each source of social support usually have independent protective effects against depression, they are hypothesized to also influence each other. This rarely studied multisystemic understanding focuses on feedback loops between internal and external resources at multiple levels, as well as between resources and depressive symptoms. Using a longitudinal variant of network analysis, this study investigates how depression, physical functioning in daily life, and perceived social support from family and friends influence each other using data from a longitudinal study of resilience among adolescents in western Canada.

1. Physical functioning and social support: resilience-supporting resources for depression during adolescence

The many expected biopsychosocial changes and transitions during adolescence can be experienced as stressful and may in turn lead to depression (Rueger et al., 2016; Thapar et al., 2012; Twenge et al., 2019). The lifetime prevalence of depression shows the strongest increase during adolescence (Lewinsohn et al., 1998; Weinberger et al., 2018). Generally, depression is characterized by profound and ongoing sadness as well as a loss of interest, energy and functionality in daily life (World Health Organization, 2020). Depression is among the leading reasons for adolescent suicide (Brent et al., 1993; Glenn et al., 2020; WHO, 2019), and a significant contributor to impaired social, physical and academic functioning (Clayborne et al., 2019; Jaycox et al., 2009; Thapar et al., 2012; Wickersham et al., 2021). Furthermore, experiencing depression during adolescence significantly increases the likelihood of later depressive episodes and comorbid disorders, suicidality, social dysfunction, and socioeconomic disadvantages during adulthood (Clayborne et al., 2019; Fombonne et al., 2001a, 2001b; Johnson et al., 2018). Hence, the identification of resilience-enhancing resources against depression in adolescence has the potential to change a young person's future trajectory across the lifespan.

An individual shows resilience when meaningful resources are available and used in ways that support positive development and adaptive functioning despite exposure to significant stress (Ungar and Theron, 2020). This perspective states that an individual should have a higher likelihood of showing resilience in the face of depression if the individual can support themselves as well as receives adequate support from their social and physical environment.

Physical functioning and physical activity have repeatedly been found to support resilience in the face of adolescent depression with low to moderate effects (Hu et al., 2020; Oberste et al., 2020). While physical functioning relates to fundamental activities that are essential for daily living such as walking, lifting, eating, dressing, etc., physical activity relates to voluntary behaviors or performances that usually aim at maintaining or increasing physical fitness, strength, and/or functioning (DiPietro, 1996). Hence, physical functioning can be seen as a fundamental means of individual support in all physical activities of daily life, and is, therefore, essential for behavioral activation in the treatment of depression. For this reason, this study focused on physical functionality.

Obesity (Schwimmer et al., 2003) or chronic illnesses such as asthma (Cui et al., 2015) have been identified as potential threats to physical functioning that could lead to depressive symptomatology during adolescence. Furthermore, symptoms such as a general loss of interest and energy in any (daily) activity likely limit physical functioning in adolescents (Jerstad et al., 2010; WHO, 2020). However, longitudinal studies suggest that present depressive symptomatology has a more significant effect on shorter-term than longer-term physical functioning (Jaycox et al., 2009; Keenan-Miller et al., 2007).

Social support (SS) is a fundamental resilience-enhancing resource in the face of adversity across cultures and contexts (Ungar, 2008) with different sources of support (e.g., parents, peers, etc.), the received type and amount of support (e.g., instrumental, informative, emotional) and its perceived quality determining its impact on outcomes (Dumont and Provost, 1999; Rueger et al., 2016). According to the direct-effect model of social support (Cohen and Wills, 1985; Cohen, 2004), SS fosters resilience to depression by providing experiences that elevate positive affect and lower negative affect during stressful and non-stressful times. These universal positive effects, along with the positive effects of situation-specific actions of the social network in response to an individual's stressful situation (the stress-buffering effects of SS), are likely the result of the fundamental need of humans for social interaction, community integration and appreciation for one's contributions (Cohen and Wills, 1985).

While different sources of SS mostly seem to have protective effects against adolescent depression (Colarossi and Eccles, 2003; Rueger et al., 2010), there is evidence of different magnitudes of protection. A meta-analysis of 341 SS studies showed that the close family seems to have the strongest positive effects on human wellbeing followed by the general peer group, teachers, and close friends (Rueger et al., 2016). Of note, some studies found that family support has a unique protective effect that goes beyond the collective effect of all available sources of SS (McMahon et al., 2013; Pössel et al., 2018). Nevertheless, even though family support seems to play an important role for resilience to adolescent depression, adolescence is known as a period when coping behaviors change: sources of social support outside of the family, especially from peers, become increasingly important during this life stage due to incremental changes to the autonomy and independence of adolescent from their families in western societies (Zimmer-Gembeck and Skinner, 2016). Hence, it is arguably of importance to study simultaneously the effects of different sources of SS on adolescent depression and their mutual dependence.

2. A multisystemic model of resilience to depression

According to the multisystemic model of resilience (Masten, 2014; Scheffer et al., 2018; Ungar and Theron, 2020), resources within and across different resource systems (e.g.,

physiological, psychological, social, ecological) can reciprocally influence each other in their functionality, availability, and/or accessibility. Hence, this model of resilience simultaneously accounts for the mutual dependence of different resources, as well as their influence on depression and how they could be influenced by depression over time (i.e., bidirectionality, feedback loops) (Lunansky et al., 2020).

While there seems to be a lack of research on the reciprocal effects of different resources in the context of adolescent depression, studies exist that have researched either the effects of SS on depression (see above) or the effects of depression on SS. The latter studies usually investigate scar or erosive effects of depression which predict lowered SS due to depression (Patten et al., 2010). Longitudinal studies with adolescents showed that an increasing severity of depression is associated with decreasing SS from peers and parents as well as a decreasing social network size over time (Jaycox et al., 2009; Leskelä et al., 2008). The main challenge with decreasing SS is that it has a stronger positive effect on adolescent depression than the negative effect of increasing SS (Cornwell, 2003). Related research, however, has shown that this erosion may not affect all sources of SS in the same way. A longitudinal study (three assessments over the course of two years) with middle-school girls from southwest USA ($N = 496$, age range = 11–15 years) showed that only peer support decreases over time in the context of adolescent depression, but not parental support (Stice et al., 2004).

3. The current study

Patterns of temporal reciprocity between diverse sources of support (individual and social) and mental health outcomes can be studied by applying a systems model of resilience (Lunansky et al., 2020; Ungar and Theron, 2020). Such a model investigates potential unidirectional as well as bi-directional relationships (i.e., feedback loops) between all variables. It is, therefore, the aim of this study to examine simultaneously the potential reciprocal relationships between depression, physical functioning in daily activities, perceived family support, and perceived friend support as presented in Fig. 1 using longitudinal data.

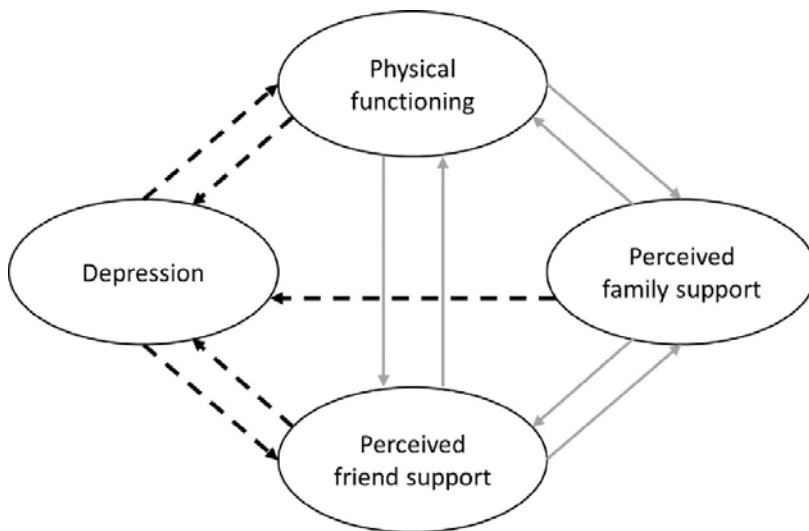


Fig. 1. Conceptual Model

Note. Black arrows indicate the hypothesized temporal effects based on the literature (confirmatory analyses). Gray arrows indicate explorative analyses. Straight lines indicate positive effects; dashed lines indicate negative effects.

Fig. 1 also illustrates our hypotheses. Based upon the above presented literature on adolescent depression (black arrows in Fig. 1), we hypothesized a negative feedback loop between depression and physical functioning with physical functioning having a stronger effect on depression than vice versa, especially in the short-term (Jerstad et al., 2010), and a negative feedback loop between depression and friend support (Stice et al., 2004). Also, only a negative temporal effect of family support on depression was expected (McMahon et al., 2013; Pössel et al., 2018; Stice et al., 2004). Since there is a lack of studies on the temporal interplay between this study's resources in the context of adolescent depression, we hypothesized positive feedback loops between the resources based on past studies on multisystemic resilience (gray arrows in Fig. 1; Höltge et al., 2020, Höltge et al., 2021).

4. Methods

4.1. Procedure

Data was used from the Resilient Youth in Stressed Environments (RYSE) project [blinded-for-review]. RYSE investigated multisystemic resilience-supporting factors and processes of adolescents (age range: 14–24 years; Sawyer et al., 2018) who live in communities dependent on the oil and gas industry in Canada and South Africa. During the course of the research, the communities experienced the worst recessions in their histories and reported significantly elevated levels of unemployment, family strain, as well as adolescent anxiety and depression. The study was approved by each principal investigators' Institutional Review Board [blinded-for-review]. Because both communities are so different from each other culturally and economically, we only used the Canadian data.

The research was guided by local advisory committees (LACs) that consisted of key stakeholders who worked with youth (e.g., schools, youth services) or in dominant industries in the community, as well as adolescents themselves. The LACs helped with participant recruitment as the study was specifically interested in local adolescents being significantly affected by changing economic conditions (booms and busts), and the selection of appropriate research methods for the community's adolescents. The LACs further helped with the rewording of items of the survey to better fit the local context and age group. The completion of the survey took about one hour and the participants were compensated with a small honorarium paid in cash or as a gift card.

Inclusion criteria were: (a) resident of the respective community, (b) between 14 and 24 years old, and (c) proficient in English. Online and paper-pencil surveys were administered in 2018, 2019, and 2020. All participants signed an informed consent form prior to participation and received monetary reimbursement at each assessment.

4.2. Participants

The sample consisted of $N = 500$ participants in 2018, $N = 294$ in 2019, and $N = 306$ in 2020, of which $N = 227$ participated at all three measurement points (see Table 1).

Table 1. Sample Characteristics.

	2018 (N = 500)			2019 (N = 294)			2020 (N = 306)		
	M	SD	Ω [CI]	M	SD	Ω [CI]	M	SD	Ω [CI]
Age (years)	18.49	3.01	–	18.30	3.15	–	18.18	3.16	–
Sex (female)	56.40%	–	–	65.00%	–	–	61.20%	–	–
Race									
White	79.60%	–	–	79.70%	–	–	81.80%	–	–
Indigenous	13.70%	–	–	13.70%	–	–	12.60%	–	–
Others	6.70%	–	–	6.60%	–	–	5.60%	–	–
Student (yes)	65.40%	–	–	55.3%	–	–	56.40%	–	–
Smoking (never)	54.60%	–	–	. ^a	–	–	60.80%	–	–
Alcohol (never)	16.40%	–	–	. ^a	–	–	15.00%	–	–
Overall depression	15.72	13.17	.96 [.95, 0.96]	17.08	14.57	.96 [.95, 0.97]	14.85	12.60	.95 [.95, 0.96]
Cognitive-affective symptoms	11.19	10.01	.94 [.93, 0.95]	12.21	11.26	.97 [.96, 0.97]	10.37	9.60	.94 [.93, 0.95]
Somatic symptoms	4.53	3.54	.87 [.85, 0.89]	4.87	3.77	.87 [.84, 0.89]	4.48	3.46	.86 [.84, 0.89]
Physical functioning	16.03	3.25	.96 [.96, 0.97]	15.76	3.41	.95 [.94, 0.96]	16.26	3.08	.90 [.89, 0.92]
Perceived family support	8.26	2.10	.84 ^b	7.98	2.14	.85 ^b	8.30	2.02	.86 ^b
Perceived friend support	12.77	2.98	.93 [.92, 0.94]	12.40	3.14	.94 [.93, 0.95]	13.14	2.86	.97 [.96, 0.97]

Note. Ω = Omega coefficient for scale reliabilities and their respective confidence intervals. ^a not assessed in 2019. ^b Family support was indicated via two items and thus Spearman-Brown was used to indicate this scale's reliability.

4.3. Measures

Reliabilities of all scales can be found in Table 1 for each assessment. Correlation tables for each assessment can be found in the online supplemental material.

4.4. Physical functioning

A person's ability to support oneself in basic daily physical tasks was assessed via the physical functioning sub-scale of the 20-item version of the Medical Outcomes Study questionnaire (Stewart et al., 1988). The scale consists of six items that ask for how long the participants have felt limited in different daily activities because of their health (e.g., walking one block, climbing stairs) using a three-point Likert scale (1 = "Limited for more than 3 months", 2 = "Limited for 3 months or less", 3 = "Not limited at all"). The sum-score ranges from 6 to 18; higher scores indicate less limitations.

4.5. Perceived family support

Family support was assessed with two items from the Child and Youth Resilience Measure – 28 (Ungar and Liebenberg, 2011): "My family have usually supported me throughout life." and "My family stands by me during difficult times." Participants rate their agreement with these items on a five-point Likert-scale (1 = "Not at all" to 5 = "A lot"). The sum-score ranges from 2 to 10; higher scores indicate higher agreement.

4.6. Perceived friend support

Friend support was assessed with the Peer Support Scale (Lerner et al., 2005). This scale consists of four items (e.g., "I trust my friends", "My friends are there when I need them") and applies a four-point Likert scale (1 = "Never true" to 4 = "Always true"). The sum-score ranges from 4 to 16; higher scores indicate higher friend support.

4.7. Depression

The level of depressive symptomatology was assessed using the Beck Depression Inventory-II (BDI; Beck et al., 1996). The BDI asks about experiences of symptoms of depression over the past two weeks. It consists of 21 items of which each consists of four symptom-specific statements, e.g., "0 = I feel the same about myself as ever; 1 = I have lost confidence in myself; 2 = I am disappointed in myself; 3 = I dislike myself". The sum-score ranges from 0 to 63; higher scores indicate higher levels of depression.

The literature on adolescent depression has shown that next to using a total sum-score, two subscales can also be used (Storch et al., 2004; Whisman et al., 2000): a cognitive-affective symptoms subscale, which consists of 16 items, and a somatic symptoms subscale, which consists of 5 items.

4.8. Data analysis

The data were analyzed using *R* version 4.0.3 in *RStudio* 1.3.1093 (R Core Team, 2020). Missing values were imputed using a random forest approach via *missForest* 1.4 (Stekhoven and Bühlmann, 2012). R-code can be found in the online supplemental material.

4.9. Network estimation

In order to simultaneously investigate autoregressive effects as well as unidirectional and bi-directional relationships, a graphical vector-autoregression model between latent variables based on panel data was estimated using *psychometrics* 0.8 (panel-lvgvar; Epskamp, 2020). The panel-lvgvar is a combination of two models: a factor/latent variable model (to account for measurement error and potential covariation among observed variables that is caused by an underlying factor) and a graphical vector-autoregression model. This is a specific type of psychometric network model which estimates the temporal co-variation of latent variables over random subjects at fixed time points (at least three measurements are needed). However, it can only indicate average effects in a population and not individual-level within-person dynamics. Specifically, a network model consists of nodes and edges. The nodes represent the variables which are connected by weighted edges. The factor models can be found in the online supplemental material.

In a panel-lvgvar, two network models can be estimated to study temporal dependencies: a temporal and a contemporaneous network (Epskamp et al., 2018; Epskamp, 2020). In the temporal network, edges represent predictive effects: they indicate if the variables in the network can predict themselves and each other over time. The weight of the edges results from the standardization of temporal within-subject effects into partial directed correlations and can be compared in their weight (Wild et al., 2010). Hence, an edge indicates the direct effect of a lagged predictor on an outcome at the next measurement by controlling for the effects of all other covariates and the outcome at the lagged measurement. Three temporal effects can be identified: unidirectional and bi-directional (i.e., feedback loop) effects between different variables, and autoregressive effects of the same variable.

A contemporaneous network controls for temporal effects and estimates within time-point partial correlations (Epskamp et al., 2018). Hence, it indicates if nodes can predict each other within the same time-point and could thus show different results to a temporal network. This network is suitable to show potential causal effects that emerge faster than between a study's measurements. The resulting edges are undirected and thus the causal pathways are hypothetical and need to be interpreted in relation to the temporal network and based on theory (Bringmann et al., 2019).

The networks were estimated using full information maximum likelihood estimation (i.e., all data was used at each timepoint) due to the varying sample sizes between the timepoints (Epskamp, 2020).

Temporal and contemporaneous network models were estimated using the BDI total score and the three resources (Model 1), and the two subscales of the BDI (cognitive-affective, somatic) and the three resources (Model 2). For each of these models, two models were estimated and compared in their model fit: a saturated and a pruned model. A saturated model includes all estimated edges independent from their standard error and significance. Pruning excludes edges from a network that are not significantly different from zero (Epskamp, 2020). Pruning is based on the standard errors of the parameters and was applied using $\alpha = 0.05$. The pruned models fit the data better than the saturated models. The statistics for the model fit can be found in the online supplementary material. Overall, the model with the two BDI subscales and pruning showed the best fit. Hence, pruned model 2 was chosen for interpretation and pruned model 1 can be found in the online supplementary material.

The networks were visualized using *qgraph* (Epskamp et al., 2012). The stability of the network estimations was investigated by re-estimating the final models with 200 case-drop bootstrap samples that consisted of 75% of the original sample (Epskamp, 2020). This procedure shows how many times an edge is included in all re-estimated models. The more networks include the same edge, the more stable is the estimation of that edge.

5. Results

The temporal network (Fig. 2A) shows that all three resources positively predicted themselves over the three assessment waves, while somatic as well as cognitive-affective symptoms of depression did not show any autoregression. The following unidirectional temporal effects were found: family and friend support each had a negative effect on both depression subscales over time, while no temporal effects were estimated for the depression subscales on family and friend support. Also, a reinforcing feedback loop was estimated between family and friend support that indicated a mutually reinforcing effect between them over time. Physical functioning had a negative effect on both depression subscales. Also, a negative feedback loop between depression and PF was estimated for the somatic subscale which indicated that high/low somatic symptoms decrease/increase PF over time, and a high/low PF in turn decreases/increases somatic symptoms. Of note, no significant temporal effects were found between the two depression subscales.

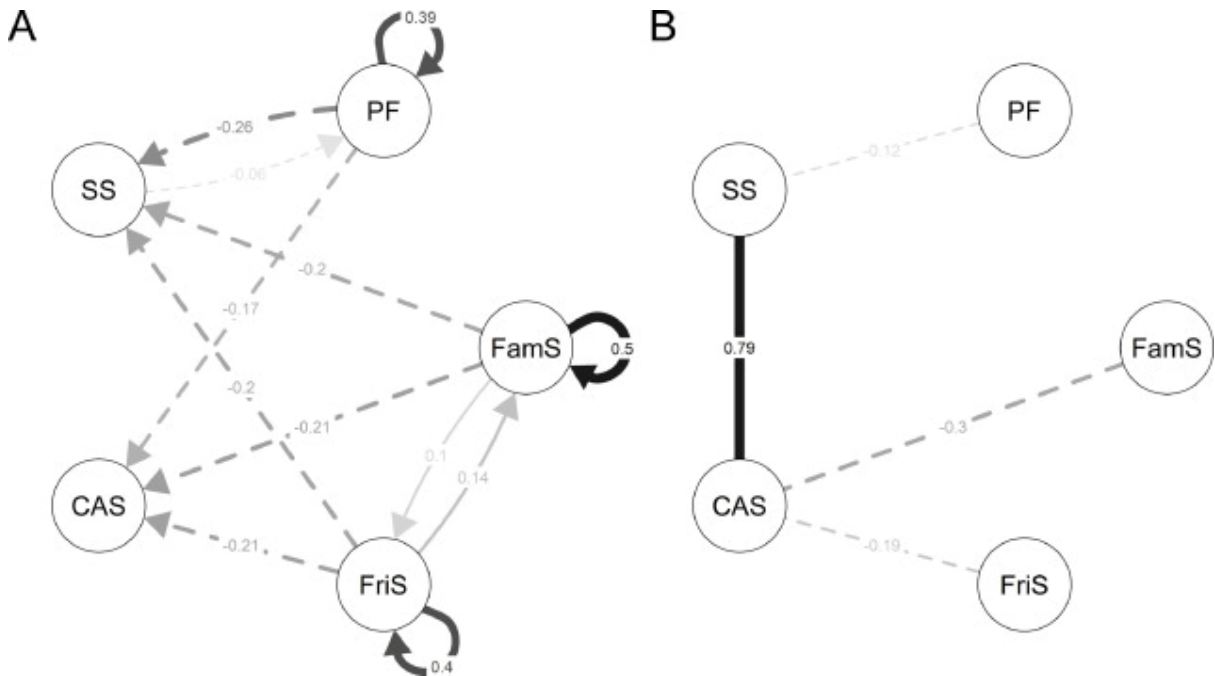


Fig. 2. Temporal and contemporaneous network for the depression subscales and the resources.

Note. A: temporal network, B: contemporaneous network. Straight edges = positive effects, dashed edges = negative effects. Thicker edges indicate stronger effects. CAS = cognitive-affective symptoms, SS = somatic symptoms, PF = physical functioning, FamS = family support, FriS = friend support.

The contemporaneous network (Fig. 2B) shows several differences to the temporal network. First, only PF and the somatic subscale showed a negative relation. Second, only family and friend support showed a negative relation with the cognitive-affective subscale. Third, the two

depression subscales shared a strong positive relation. Fourth, no relation was estimated between family and friend support.

The bootstrap results can be found in Table 2. All potential temporal effects were estimated, even though some were only present in 2% of the bootstraps. The most stable effects were found for the autoregressive effects of family and friend support, as well as the positive effect of family on friend support, and the negative effect of physical functioning on somatic symptoms. The least stable effects were found for the negative effect of friend support on cognitive-affective symptoms and somatic symptoms on physical functioning.

Table 2. Stability Analysis.

Variable	1	2	3	4	5
A Temporal network					
1. Physical functioning	81	4	31	26	91
2. Perceived family support	25	194	95	47	62
3. Perceived friend support	3	36	121	9	28
4. Cognitive-affective symptoms	21	44	23	72	48
5. Somatic symptoms	25	3	11	14	27
B Contemporaneous network					
1. Physical functioning	–				
2. Perceived family support	32	–			
3. Perceived friend support	34	112	–		
4. Cognitive-affective symptoms	38	179	173	–	
5. Somatic symptoms	98	21	32	200	–

Note. Number of times (A) temporal and (B) contemporaneous effects were included in 200 networks that were based on a random subsample of 75% of the original sample. Bold-faced values indicate parameters that were included in the full sample.

With regard to the contemporaneous network, relationships between all variables were found. The least stable effect was found between physical functioning and somatic symptoms (in 49% of the subsamples). A relationship between family and friend support was found in over half of the subsamples which was not present in the full sample.

6. Discussion

This study applied a multisystemic model of resilience by investigating the temporal interplay of cognitive-affective and somatic symptoms of depression, personal resources (physical functioning in daily activities, PF) and social resources (generally perceived support by family and friends) in a sample of adolescents from a rural town in Western Canada over the course of three years. Unidirectional, bi-directional (i.e., feedback loops), and carryover effects of these variables were studied using longitudinal data and panel network analysis. Our aim was to investigate how these resources influence each other and how they relate to depression over time. Long- and short-term effects were studied.

6.1. Dynamics of cognitive-affective and somatic symptoms of depression

Both depression factors did not show a significant carryover between consecutive timepoints, which indicates fluctuation over time. Hence, the studied sample probably experienced episodic rather than chronic depression during the three-year timeframe of the study. Furthermore, while a strong positive relationship was found between the two depression factors

in the short-term, no unidirectional effect or feedback loop was found between them over the course of the study. This might indicate that while the studied depression factors condition each other in the short-term, they might not mutually influence each other in the longer-term for the studied sample. This speaks to the episodic character of depression and the possibility that depression is a fast rather than slow-evolving psychopathology (Lunansky et al., 2020).

6.2. Dynamics of physical functioning and social support

All three resources showed significant positive carryover effects (i.e., inertia) which indicates significant stability over time (Hamaker and Grasman, 2015). While such a pattern appears advantageous for individuals with high social support and PF, it is detrimental for individuals with low social support and PF in the context of depression.

Perceived family and friend support showed a significant positive feedback loop indicating that a low/high perceived family support at a lagged measurement predicts a low/high perceived friend support at the next measurement and vice versa. Hence, these resources seem to reinforce each other over longer time periods, but not during shorter time periods. However, future research needs to take a closer look at how the family and friends of depressed adolescents influence each other in their supportive behavior and how this unfolds over time.

No direct effects, however, were found between both sources of social support and PF in the short- and long-term in the studied sample. Nevertheless, from a network perspective, the effect of family and friend support on PF could have been mediated via somatic symptoms in the long-term: first, higher social support by family and friends in the past predicted lower somatic symptoms in the future and second, lower levels of somatic symptoms, which might be indicative of a higher energy level, led to higher levels of PF which in turn decreased somatic as well as cognitive-affective symptoms of depression. If social support directly affects depressive symptomatology, it may be a means to help a young person to regain the energy and ability to care for themselves in daily life which would be expected over time to also decrease depression.

6.3. Dynamics between depression, physical functioning and social support

Resource specific temporal patterns were identified: while all three resources negatively affected both symptom clusters of depression in the long-term, physical functioning only negatively affected somatic symptoms and social support only negatively affected cognitive-affective symptoms in the short-term.

The comparable unidirectional long-term effects of both social support resources are in line with past research which indicates that a lack of social support is a risk factor for developing depression during adolescence but not vice versa (Sheeber et al., 1997; Young et al., 2005). However, these unidirectional effects contrast with the literature on bidirectional and scarce or erosive effects in population and adult samples (Burns et al., 2016; Patten et al., 2010), which might be due to the rather low average levels of depression of the studied sample or that the three-year timeframe of the study was too short for such effects to be detected (Leskelä et al., 2008). Future studies might also differentiate between support from peers and support from close friends as close friends might show a higher stability in their supportive behavior than peers.

These unidirectional effects seem to further indicate that social support has a longer-term resilience-supporting effect (higher social support at a lagged timepoint predicted lower depression at the next timepoint). Family and friend support showed similar effects over the course of the study, while family support showed a stronger effect on depression in the short-term. This gives further evidence that family support seems to have a stronger impact on adolescent depression than friend support (McMahon et al., 2013; Rueger et al., 2016). Past studies have found comparable temporal patterns (Young et al., 2005; Herman-Stahl and Petersen, 1999; Sheeber et al., 1997) which might indicate that timely social support is of high importance for a young person's mental health, while a multisystemic pool of different resources seems essential for their resilience in the long-term (Höltge et al., 2021; Ungar and Theron, 2020). Such timely social support needs appropriate psychoeducation of the family and friends so that they understand depression and can adequately support affected persons.

In relation to physical functioning, results showed a negative effect on cognitive-affective symptoms and a negative feedback loop with somatic symptoms related to depression in the long-term. This latter finding should be due to the conceptual overlap of PF and somatic symptoms since both ask about somatic/physical functioning. This might explain why no effect of the cognitive-affective factor on PF was found, but only a negative effect of somatic symptoms on PF. Nevertheless, these results could indicate that maintaining PF that is necessary to manage daily activities and avoid chronic or lifestyle-related disorders can have a protective effect against both facets of depression, while only somatic symptoms might negatively influence PF.

Within the feedback loop, PF showed a stronger negative effect on somatic symptoms than vice versa. From a risk perspective, this provides further support that poor PF and associated low levels of physical activity increase adolescent depression (McMahon et al., 2017) and that depression lowers the ability to (physically) care for oneself in daily life (Roshanaei-Moghaddam et al., 2009; WHO, 2020). From a resilience perspective, our results show that the longer-term protective function of PF in daily activities should be just as important as its short-term protective effect. Thus, family and friends should be educated in how best to support depressed adolescents by, for example, knowing how to motivate them to be physically active and doing physical activities of daily life together (Nyström et al., 2015).

Comparing the short- and long-term dynamics of the studied resources seems to indicate that timely resilience interventions need to be tailored to the dominant symptoms that are present and that the assessed resources of this study seem to be protective against both depression components in the longer-term. Hence, this study points to potential time-dependent effects of different resources on adolescent depression: timely interventions might be most effective if they target meaningful resources for a young person's current specific situation while interventions with a longer-term, preventative focus should rather build a set of globally effective promotive and protective resources such as social support and PF. Seeing depression as a fast-evolving psychopathology would indicate that social support could affect somatic symptoms via cognitive-affective symptoms even in the short-term.

6.4. Limitations and future studies

A shortcoming of the study is the differing sample size between measurements even though the statistical method applied full information maximum likelihood estimation. Hence, better participant retention is warranted. This would also make accurate group comparisons by meaningful covariates such as gender, age, socioeconomic status or experienced stress in the

structure and functioning of temporal networks possible (Höltge et al., 2020; Thoma et al., 2020). For example, gender is known to crucially affect the onset and symptomatology of depression in adolescence (Addis, 2008; Salk et al., 2016). Also, specific symptom-clusters of depression could occur in relation to different adverse experiences (Fried et al., 2014) which in turn might need different resources to show resilience (Ungar, 2017). Such contextualized models need to be researched in future studies that should also investigate if the dynamics of the studied model can be replicated among younger and older age groups.

This study's sample had a rather low average of self-reported depressive symptomatology which might be responsible for the missing negative influence of depression on social support over time (Cornwell, 2003; Jaycox et al., 2009; Leskelä et al., 2008). This was also in contrast to the perceived high depressiveness of the community's adolescents by local advisors to the study, which might be explained by a social desirability bias on the part of participants. Hence, future studies should include sub-clinical and clinical populations and also apply objective measures of depression. In this context, it would be important to prevent systematic dropout related to the participants depression status which could bias the model's estimates.

In relation to the resources, future studies should assess more sources of social support that could be significant for adolescent resilience such as teachers, the general peer group, or romantic partners (Rueger et al., 2016). In this context, the chosen definition of adolescence and related age range likely encompasses adolescents that live either at their parents or in their own home. This could influence the dynamics between different sources of social support and their effect on depressive symptomatology and calls for group comparisons in future studies. Further, since depression can negatively bias how support is perceived (Park et al., 2016), objective measures (e.g., time spent together, evaluation by the persons who give support) of different types of social support (emotional, instrumental, etc.) should be assessed. Relatedly, this study used rather global evaluations of social support which might not have changed during the studied period, and the items on family support assessed support in different time frames. Hence, instruments should be used that coherently evaluate social support as it is perceived at present. Further, to understand how different sources of support influence each other in their support behavior, respective quantitative items or qualitative assessments should be included. Also, psychological (e.g., self-efficacy, personality traits) and physiological (e.g., Cortisol, inflammatory markers) factors that are important for resilience in the context of depression should be assessed concurrently with social supports (Fritz et al., 2018; Lunansky et al., 2020).

Finally, even though the applied analysis method can handle longitudinal data with varying sample sizes, the stability analysis calls for replication studies with a higher number of participants and assessments. The bootstrapped results point to the existence of more relationships and questions the existence of some estimated relationships. Hence, future studies should apply more comprehensive survey assessments combined with experience sampling methods to better capture the episodic character of depression and its interplay with internal and external resources.

7. Conclusion

The current longitudinal study (three years, three assessments) applied a multisystemic model of resilience by investigating the temporal interplay between depression (cognitive-affective and somatic symptoms), physical functioning in daily life, and perceived social support from one's family and friends using network analysis. The results were representative of an episodic character of adolescent depression, while the investigated resources tended to be relatively

stable over the course of the study. Only physical functioning was found to be negatively affected by depression, especially by somatic symptoms, while both sources of social support were not affected by depression over time. Nevertheless, family and friend support showed a reinforcing feedback loop, though they did not interact with physical functioning over time. The study encourages awareness of potential time-dependent effects of the investigated resources on depressive symptomatology.

Contributors

JH did the statistical analyses and primarily prepared the manuscript which was further edited by LT and MU. LT and MU are the PIs of the RYSE project. All authors have approved the final article.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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