

A Cross-Sectional Network Analysis of Physical Exercise, Sleep Procrastination, Health Attitudes, Self-Control, and Short-Video Addiction Symptoms among College Students

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Article

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Abstract

Background

Immediate reward mechanisms in short-video algorithms are closely associated with short-video addiction among college students, which often co-occurs with sleep procrastination and reduced self-control. Existing studies have mainly used serial mediation models to examine linear pathways, rarely adopting a systemic network perspective to characterize coordinated and balancing relationships among multiple variables.

Methods

A Gaussian graphical model-based network analysis was conducted among 810 college students. Participants completed measures of physical exercise, short-video addiction, sleep procrastination, health attitude, and self-control, including impulse control, resistance to temptation, work execution, moderation of entertainment consumption, and health habits. A multivariable association network was constructed, followed by gender-specific network comparisons and stability tests.

Results

Positive and negative associations existed among variables, with the strongest associations within the self-control submodule. In the overall network, sleep procrastination showed the most negative expected influence, whereas impulse control showed relatively positive expected influence. Health attitude and work execution showed relatively high positive bridge expected influence. Physical exercise and health attitude showed more prominent positive bridging in males, whereas work execution and resistance to temptation showed higher cross-module connectivity in females. After 5,000 bootstrap resamples, stability coefficients for edge weights and centrality indices all exceeded 0.71, betweenness was less stable, indicating a robust and reliable model.

Conclusions

Sleep procrastination and impulse control are closely associated with short-video addiction in college students. Physical exercise, health attitude, and short-video addiction are linked to sleep procrastination across modules, with exploratory gender-stratified differences in association patterns. These findings provide network-based evidence for universities to design differentiated interventions targeting health behaviors, self-control training, and sleep.

1 Introduction

Digital media are deeply integrated into university campuses. The fragmented content and frequent positive feedback of short videos have made them a mainstream leisure activity, while prolonged or poorly controlled short-video use has been associated with problematic use/addiction symptoms among college students^[1]. Lapierre et al. found that smartphone dependence significantly predicted adolescents' loneliness and depressive symptoms, suggesting an association between smartphone dependence and poorer psychological well-being^[2]. Dong Wei's master's thesis examined self-regulation and sleep procrastination as serial mediators between short-video addiction and sleep quality^[3]. Short-video addiction can crowd out sleep, disrupt daily rhythms, and trigger sleep procrastination^[4]. Although recent research has addressed mechanisms linking short-video addiction to sleep quality, limitations remain in variable relationship models, self-control dimensionality, and gender heterogeneity. This review focuses on four core variables: physical exercise, sleep procrastination, health attitude, and self-control.

Physical exercise is an important health behavior among college students. It has a significant negative predictive effect on internet addiction, mediated by self-control^[5]; self-esteem and self-control also mediate physical activity–internet addiction associations^[6]. In short-video addiction, leisure-time physical exercise indirectly affects addiction through mediators such as self-control^[7], and 8-week yoga practice significantly intervenes in female college students' short-video addiction^[8]. However, these mediation studies provide limited information about conditional associations among multiple co-occurring variables. Zhao et al. confirmed through serial mediation that physical exercise could relieve both short-video addiction and sleep procrastination, but this only verified linear pathways and could not identify exercise's bridging hub value in a multivariable network, leaving unclear why equal exercise produces different intervention effects^[9]. Pu Yuxue et al. noted that physical exercise is a healthy alternative for coping with negative emotions and reducing compensatory short-video use, but its protective effect depends on health cognition and self-control, and single-variable models ignore interactive checks and balances^[10].

Sleep procrastination is an increasingly prominent health risk behavior among college students. Zhang Yifan et al. found via diary method that perceived stress induced sleep procrastination through ego depletion^[11]. Academic stress also affects sleep procrastination, with ego depletion and attitude toward staying up late playing multiple mediating roles^[12]. Short-video addiction directly affects sleep procrastination and indirectly influences it by impairing sustained attention and weakening self-control, which is negatively correlated with sleep procrastination^[13]. In excessive short-video use and sleep quality, bedtime delay mediates and self-control moderates^[14]. However, most studies treat sleep procrastination as a serial mediator, assume unidirectional causal transmission, and have not examined its hub status and cross-module risk transmission in a multivariable system. Gou Hao et al. used network analysis and found sleep-related behaviors to be core risk nodes in internet addiction, with sleep disruption depleting prefrontal inhibitory functions and amplifying addictive behaviors, but protective variables such as physical exercise and health attitude were absent, preventing a complete risk–protection balance network^[15].

Health attitude, a cognitive antecedent of health behaviors, has gained increasing attention. Sleep apps combined with new-media sleep education positively affect college students' sleep quality^[16]. In circadian rhythm–sleep quality relations, sleep beliefs and attitudes play a serial mediating role^[17]. Cheng Yang et al. found that anxiety mediates and self-concept moderates the pathway from short-video addiction to sleep quality^[18]. Yet health attitude has mostly been treated as a single predictor rather than integrated with addiction, procrastination, and self-control, leaving its cross-module bridging function unclear.

Self-control is a key psychological resource for behavioral regulation. Tan Shuhua and Guo Yongyu's revised college student self-control scale established five dimensions: impulse control, health habits, resistance to temptation, work execution, and moderation of entertainment consumption. Self-control mediates the relationship between short-video addiction and sleep procrastination^[13]. Cao Yuanlong et al. found that self-control indirectly affects bedtime procrastination through future time perspective^[19]. Low self-control affects college students' physical exercise through serial mediation by sleep procrastination and negative emotions^[20]. Ye Na et al. confirmed via diary method that self-control mediates daily physical activity–sleep quality^[21]. However, most studies model only total self-control scores without distinguishing sub-dimension network functions, leaving stratified associations in the addiction–sleep vicious cycle unclear. Lyu Lihua et al. used Bayesian networks to explore addiction risk nodes but did not decompose self-control sub-dimensions, limiting precise intervention targets^[22].

Methodologically, most existing studies use structural equation modeling or serial mediation models, focus on unidirectional hypotheses, and fail to identify complex checks and balances among coexisting variables. Psychological network analysis, specifically the Gaussian graphical model, provides a complementary way to characterize conditional associations and node connectivity within a multivariable system by using centrality indices to distinguish core risk nodes, protective nodes, and cross-module bridging nodes. It has been applied to behavioral addictions such as online gaming addiction^[23], but not to the integrated system of short-video addiction, sleep procrastination, and physical exercise. Male and female students differ in short-video usage motivation and self-control resource allocation^[24], yet few studies construct gender-specific networks, hindering precision intervention plans.

Accordingly, this study uses network analysis to integrate nodes—physical exercise, health attitude, short-video addiction, sleep procrastination, and five self-control dimensions—into an association network. Three questions are proposed: (1) What are the overall network structure characteristics, and which variables serve as core hubs or cross-module bridging nodes? (2) What are the hierarchical patterns of positive and negative expected influence of core nodes, and what functions do sleep procrastination and impulse control assume? (3) What significant differences exist between male and female college students in network structure and bridging functions?

This study aims to characterize the cross-sectional association structure and cross-community connectivity among the study variables, providing refined evidence for mental health education, physical exercise interventions, and sleep management in higher education institutions.

2 Methods

2.1 Participants and Procedure

This study recruited full-time undergraduates via convenience sampling from institutions across Shandong,Guangdong,Hunan,Heilongjiang,Beijing,Hubei,and Chongqing,including Hunan University of Technology,Guangzhou Sport University,and Hunan Agricultural University.Online questionnaires were distributed through Wenjuanxing from February to May 2026 via class groups and campus communities.Informed consent,anonymity,and voluntary withdrawal were ensured.Invalid responses(completion<120s,>80%consecutive repeats,or patterned responding)were excluded.Of 991 collected questionnaires,810 valid responses were retained(81.7%).All procedures were performed in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the Faculty of Psychology, Beijing Normal University. Meanwhile, informed consent was obtained from the participants and their legal guardians.

Sample distribution is shown in Table 1.Participants were 359 males(44.3%)and 451 females(55.7%);freshmen 421(52.0%),sophomores 265(32.7%),juniors 69(8.5%),seniors 55(6.8%).Mean age was 20.3 years(SD = 1.5;range 18–24).All could independently use short-video applications and manage daily routines and physical activity.

Table 1
Demographic composition of the sample(N = 810)

Dimension	Category	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Gender	Male	359	44.3	44.3	44.3
	Female	451	55.7	55.7	100
	Total	810	100	100	-
Grade	Freshman	421	52.0	52.0	52.0
	Sophomore	265	32.7	32.7	84.7
	Junior	69	8.5	8.5	93.2
	Senior	55	6.8	6.8	100
	Total	810	100	100	-

2.2 Measures

2.2.1 Physical Activity Rating Scale(PARS-3)

The Physical Activity Rating Scale(PARS-3),revised by Liang Deqing^[25],was used to measure college students'physical exercise behaviors over the past month.The scale consists of three single-choice

items, each rated on a 5-point scale, assessing exercise intensity, duration per session, and frequency per week. The total exercise volume was calculated as: exercise volume = intensity score × duration score × frequency score. Total scores ranged from 0 to 100, with higher scores indicating greater overall physical activity. Because the raw data showed relatively high skewness and kurtosis, a logarithmic transformation (log physical exercise) was applied to the total scores in subsequent analyses to meet normality assumptions. The internal consistency Cronbach's α for this scale was 0.816, and the test-retest reliability was 0.82, meeting psychometric standards.

2.2.2 short-video addiction Scale

This study adopted the classic Young Internet Addiction Scale (IAD-8) and adapted it to the local context^[26]. We retained the 8 core addiction dimensions of the original scale (craving, tolerance, loss of control, withdrawal, exceeding time, functional impairment, concealment, and emotional escape) and replaced "internet use" with "short-video browsing" to form an 8-item short-video addiction scale. Items were rated on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). Higher total scores indicated more severe short-video addiction. In this study, the Cronbach's α for the total scale was 0.84.

2.2.3 Chinese Version of the Sleep Procrastination Scale (BPS)

The Sleep Procrastination Scale revised by Kroese et al.^[27] was used, and some items were modified to fit the present study. The scale has 9 items and a single-factor structure, and it includes reverse-scored items. It uses a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). A higher total score indicates more serious sleep procrastination. The internal consistency of the scale was Cronbach's α = 0.92. It is suitable for measuring sleep behaviors among Chinese college students.

2.2.4 Health Attitude Scale

This study used the Health Awareness Measurement Scale developed by Dutta-Bergman et al. and made appropriate adaptations^[28]. The scale consists of 5 items (e.g., "Living as healthily as I can is very important to me"). The items were designed around health value cognition, proactive health management, and disease prevention attitudes. Each item is rated on a 5-point Likert scale, with higher total scores indicating stronger health cognition and positive health attitudes. The Cronbach's α for the total scale was 0.72. The item content strictly followed the logic of the health cognition-health behavior chain, consistent with the health attitude measurement framework of Li Liqiang et al.^[29].

2.2.5 Self-Control Scale for College Students (SCS)

The Chinese version of the Self-Control Scale for college students, revised by Tan Shuhua and Guo Yongyu^[30], was used. It contains 19 items and is divided into five sub-dimensions: impulse control, health habits, resistance to temptation, work execution, and moderation of entertainment consumption. These five dimensions correspond to the five self-control sub-nodes in our network analysis. Items are rated on a 7-point Likert scale, with some items reverse-scored. Higher total scores indicate higher levels of

self-control. The Cronbach's α for the full scale was 0.862, and the test-retest reliability was 0.85, meeting reliability standards.

2.3 Statistical Analysis

Harman's single-factor test was used to examine common method bias. The raw physical exercise scores were log-transformed to correct skewness. Subsequently, nine core variables were included in the analysis: physical exercise (log-transformed), short-video addiction, sleep procrastination, health attitude, and the five sub-dimensions of self-control (impulse control, health habits, resistance to temptation, work execution, and moderation of entertainment consumption). Partial correlation analysis and heatmap visualization were first conducted to preliminarily reveal the direct association patterns among variables. On this basis, a multivariate association network was constructed using the Gaussian graphical model (GGM). Variables were grouped into three modules according to their functions: protective, risk, and self-control. Four centrality indices (strength, closeness, betweenness, and expected influence) were calculated, and bridge expected influence was additionally introduced to identify key nodes that transmit effects across modules. This approach moves beyond the limitations of traditional linear models that can only test unidirectional effects, allowing us to estimate conditional associations and identify nodes with relatively high cross-community connectivity from a systemic interaction perspective. To ensure model robustness, 5000 bootstrap resamples were performed to test the precision of edge weights and the stability of centrality indices. Network comparison tests (NCT) were conducted to examine gender differences in network structure, systematically assessing heterogeneity between male and female college students in core node influence and bridging functions. The combination of network analysis and resampling techniques not only depicts the complex topological structure of coordinated checks and balances among multiple variables, but also quantifies the relative importance of each node and its cross-module transmission strength within the overall system, providing an exploratory basis for identifying candidate variables for future longitudinal or intervention research. The entire analytical procedure is comprehensive and reproducible, offering a standardized paradigm for network modeling based on cross-sectional data in health behavior research. It facilitates a methodological shift from a "variable-centered" to a "system-centered" approach in studies of short-video addiction and sleep procrastination, thus better reflecting the interactive nature of real-world behavioral systems. All network analyses were performed using the *qgraph* and *bootnet* packages in R. The EBIC glasso algorithm was employed for sparse network estimation. Blue edges represent positive partial correlations and red edges represent negative partial correlations, with edge thickness indicating association strength. This standardized analytical workflow has been widely adopted in domestic mental health network research and demonstrates good replicability^[31].

3 Results

3.1 Common Method Bias Test

Harman's single-factor test was used to extract unrotated common factors from all scale items. The variance explained by the first factor was 35.87%, which is below the critical threshold of 40%, indicating that no dominant single-factor evidence was found in this study. The data were therefore suitable for subsequent statistical analyses.

3.2 Descriptive Statistics and Normality Test

For all variables, the mean, standard deviation, skewness, and kurtosis were examined for normality (see Table 2). For short-video addiction, sleep procrastination, impulse control, health habits, resistance to temptation, work execution, moderation of entertainment consumption, and total self-control score, the absolute values of skewness and kurtosis were all within acceptable ranges, approximately conforming to normal distributions. Health attitude showed mild negative skewness, which still met the requirements for statistical analysis. The raw physical exercise variable showed significant right skewness (skewness = 1.625, kurtosis = 2.156). After logarithmic transformation, the skewness became -0.172 and kurtosis = 0.923, indicating a near-normal distribution. Thus, the log-transformed physical exercise variable was used in the subsequent network analysis. With a sample size of $N = 810$, all variables satisfied the normality assumptions required for Gaussian graphical model analysis.

Table 2
Descriptive statistics and normality tests for each variable(N = 810)

Variable	N	Mean	SD	Skewness -Statistic	Skewness -SE	Kurtosis -Statistic	Kurtosis -SE
Physical Exercise	810	17.21	20.901	1.625	0.086	2.156	0.172
Short-video addiction	810	27.42	9.054	0.065	0.086	-0.167	0.172
Health Attitude	810	27.43	5.385	-0.88	0.086	1.359	0.172
Sleep Procrastination	810	37.56	9.23	-0.417	0.086	0.867	0.172
Impulse Control	810	32.17	7.504	0.111	0.086	-0.016	0.172
Health Habits	810	17.34	4.287	0.106	0.086	0.221	0.172
Resistance to Temptation	810	8.11	2.3	0.1	0.086	0.353	0.172
Work Execution	810	12.94	3.085	0.092	0.086	0.854	0.172
Moderation of Entertainment Consumption	810	12.96	3.676	-0.03	0.086	-0.155	0.172
Self-Control Total Score	810	83.51	16.702	0.274	0.086	0.658	0.172
PhysicalExercise (log)	810	0.949	0.567	-0.172	0.086	-0.923	0.172
ValidN(listwise)	810						

3.3 Variable Correlation Analysis

Partial correlation analysis was performed on the nine core variables, and a partial correlation heatmap was drawn (Fig. 1) to visually present the conditional associations among variables after controlling for others. The results showed that both positive and negative partial correlations existed. Short-video addiction had a moderate positive partial correlation with sleep procrastination ($r = 0.44$). Short-video addiction showed significant negative associations with impulse control (-0.48), resistance to temptation (-0.40), and health habits (-0.48) respectively. Sleep procrastination showed strong negative partial correlations with resistance to temptation ($r = -0.58$) and health habits ($r = -0.57$). Health attitude had a moderate positive partial correlation with work execution ($r = 0.31$). The five sub-dimensions of self-control (impulse control, health habits, resistance to temptation, work execution, and moderation of entertainment consumption) generally showed higher internal correlations within the self-control module, with impulse control and health habits showing particularly strong correlations. In

contrast, physical exercise had relatively small absolute partial correlation coefficients with all other variables, indicating weak direct conditional associations. This suggests that physical exercise showed relatively weak conditional associations with individual nodes but comparatively higher bridge expected influence; this pattern does not establish mediated or indirect effects. This finding is consistent with previous research—Guo Shuwen et al., using bibliometric analysis, pointed out that the influence of physical exercise on internet addiction is often transmitted through mediating variables such as self-control^[32], which aligns with our observed pattern of weak direct effects but prominent indirect effects of physical exercise.

3.4 Network Analysis

3.4.1 Overall Network Structure

A regularized partial correlation network with nine variables was constructed based on the Gaussian graphical model (Fig. 2). The nodes represented physical exercise, short-video addiction, health attitude, sleep procrastination, and the five sub-dimensions of self-control: impulse control, health habits, resistance to temptation, work execution, and moderation of entertainment consumption. The edges represented partial correlations estimated by the EBICglasso algorithm. Blue edges indicated positive associations, red edges indicated negative associations, and edge thickness indicated the strength of association. The overall topology showed relatively rich conditional associations among all nine nodes. Sleep procrastination (N4) was positioned at the geometric center of the network, connecting to multiple nodes and functioning as a hub node. Impulse control (N5), health habits (N6), resistance to temptation (N7), work execution (N8), and moderation of entertainment consumption (N9) together formed the self-control sub-module, with dense internal connections indicating close associations among the sub-dimensions of self-control. Several strong edges were observed between impulse control and health habits, health attitude and work execution, sleep procrastination and resistance to temptation, and short-video addiction and impulse control, reflecting a strongly coupled relationship among short-video addiction, sleep procrastination, and the self-control system. The coexistence of positive and negative edges in the network indicated a complex systemic relationship of both the network contained both positive and negative conditional associations among health behaviors, risk behaviors, and psychological cognitive variables.

Note

N1, Physical Exercise; N2, short-video addiction; N3, Health Attitude; N4, Sleep Procrastination; N5, Impulse Control; N6, Health Habits; N7, Resistance to Temptation; N8, Work Execution; N9, Moderation of Entertainment Consumption

3.5 Node Centrality Indices Analysis

3.5.1 Centrality Results

Standardized centrality indices for each node are shown in Fig. 3, and the detailed Z-score standardized results are provided in Table 1. Four centrality indices (Strength, Closeness, Betweenness, and Expected Influence) were calculated for all nine nodes. The network importance of different nodes was clearly differentiated. In terms of strength centrality, moderation of entertainment consumption ($z = 1.304$), health habits ($z = 0.693$), and impulse control ($z = 0.583$) had higher values, indicating stronger direct connections with other nodes. Physical exercise had the lowest strength centrality ($z = -1.780$), reflecting the weakest direct associations.

For closeness centrality, sleep procrastination had the highest value ($z = 0.998$), followed by resistance to temptation ($z = 0.647$) and moderation of entertainment consumption ($z = 0.639$), indicating that sleep procrastination was topologically closer to other nodes and occupied a core position in the network. Betweenness centrality reflected a node's ability to serve as a bridging path. Work execution ($z = 1.574$), sleep procrastination ($z = 1.201$), and short-video addiction ($z = 0.828$) scored higher, suggesting that these nodes were more likely to serve as relay paths for information transmission among different variables. Expected influence summarizes the signed connectivity of a node. Its sign and magnitude were interpreted in relation to the coding and theoretical meaning of the variables. Moderation of entertainment consumption ($z = 1.443$), impulse control ($z = 0.912$), and work execution ($z = 0.507$) had relatively high positive expected influence, making them protective nodes in the network. Sleep procrastination ($z = -1.716$) and short-video addiction ($z = -1.243$) had negative expected influence, with sleep procrastination showing the largest absolute negative value, making it the primary risk node within the network.

Across the four indices, sleep procrastination combined high closeness centrality with the largest negative expected influence, making it the core risk node in this network. Impulse control had relatively high positive expected influence and substantial betweenness potential, positioning it as a key protective node. The hierarchical pattern of centrality indices aligns with the theoretical logic of psychological network analysis, in which expected influence, as a global regulatory index, can accurately distinguish risk from protective nodes. This index has been widely used in research on addiction and sleep disorder network target identification^[31].

3.5.2 Bridge Expected Influence

Bridge expected influence measures the cross-module transmission capability of each node. Results are shown in Fig. 4, covering all nine nodes. Higher bridge expected influence values indicate stronger cross-community connectivity. Health attitude ranked first among all nodes in bridge expected influence, followed by work execution and physical exercise. These nodes showed prominent positive cross-module transmission capacity, building positive pathways among the protection module, cognitive module, and risk behavior module. In contrast, sleep procrastination had the lowest bridge expected influence in the network, and resistance to temptation also showed negative bridging characteristics. Both served as important bridging nodes for cross-module diffusion of positive or negative bridge expected influence. Overall, health attitude and work execution were the main positive

bridging nodes in this network; sleep procrastination was a risk-type bridging node requiring particular attention, as it could transmit risk effects across different sub-modules.

3.5.3 Comprehensive Evaluation of Network Stability

Network stability was assessed by 5000 bootstrap resamples for edge weight precision and centrality stability. The edge weight results (Fig. 5) showed that the edge weights estimated from the original sample generally matched well with the bootstrap means, with small overall estimation bias. Edges with larger absolute weights, such as impulse control-health habits, health attitude-work execution, and sleep procrastination-resistance to temptation, had narrower confidence intervals, indicating higher estimation stability. Weak edges with weights close to zero had wider confidence intervals, reflecting greater uncertainty. The centrality stability results from the case-dropping bootstrap (Fig. 6) showed that for strength, expected influence, and bridge strength, the correlation coefficients with the original sample results remained high after progressively reducing the sample size. Closeness centrality was relatively less stable than the other indices but still within an acceptable range. Taken together, the edge precision and centrality stability results confirmed that the nine-node Gaussian graphical model network constructed in this study had good reliability, and the most reported centrality measures showed high case-dropping stability, whereas betweenness did not; weaker edges had greater bootstrap uncertainty.

3.5.4 Network Comparison

Network comparison tests (NCT) were performed to examine cross-sectional group differences in network patterns between male ($N = 359$) and female ($N = 451$) college students (Figure 7). Analyses specified 5000 permutations, Spearman correlation, an EBIC-glasso gamma value of 0.5, and Benjamini-Hochberg (BH) correction for multiple comparisons. The global network structure difference was $M = 0.158$, $p = 0.341$. Global strength was 3.358 for the male network and 3.262 for the female network, yielding a strength-difference statistic $S = 0.096$, $p = 0.735$. Following BH correction, no statistically significant group differences emerged at the level of individual edges, and no tested node-centrality indices differed significantly by gender. Although global- and edge-level statistical differences were absent, descriptive pattern divergences in expected influence and bridge expected influence were observed across the two gender-stratified networks. At the descriptive level, distinct node-level profiles of expected influence and bridge expected influence were observed for male and female participants.

In the male subgroup, health attitude and impulse control displayed relatively high positive expected influence, whereas short-video addiction and sleep procrastination showed pronounced negative expected influence.

For the female subgroup, work execution exhibited the highest positive expected influence, followed by impulse control and health attitude; short-video addiction and sleep procrastination also presented high negative expected influence. Regarding bridge expected influence, health attitude and physical exercise

showed comparatively stronger positive cross-module associations among males. Among females, health attitude and work execution demonstrated the most prominent positive cross-module connections. Short-video addiction and sleep procrastination displayed negative bridging properties in both gender subgroups, while gender-specific variation was evident for other protective-type bridge nodes.

Specifically, cross-module connectivity strengths of work execution and resistance to temptation were comparatively higher in the female group than in the male group. This descriptive finding aligns with prior work documenting gender heterogeneity regarding associations between nighttime social-media use and sleep disturbances, in which correlations between social-media engagement and sleep-related problems tend to be more salient among women than men[24]. These cross-sectional observations reflect correlational patterns rather than causal pathways.

Note

N1:Physical Exercise;N2:short-video addiction;N3:Health Attitude;N4:Sleep Procrastination;N5:Impulse Control;N6:Health Habits;N7:Resistance to Temptation;N8:Work Execution;N9:Moderation of Entertainment Consumption

4 Discussion

Based on the Gaussian graphical model,this study systematically revealed the complex association network among physical exercise,short-video addiction,sleep procrastination,health attitude,and the multiple dimensions of self-control in college students.The overall network showed that the sub-dimensions of self-control were most densely connected internally.Sleep procrastination,with the highest closeness centrality and the most negative expected influence,constituted the core risk hub of the entire network,while impulse control,with the highest betweenness centrality and positive expected influence,served as a key protective node.Health attitude and work execution showed the strongest positive cross-module transmission effects.Although physical exercise had weak direct associations,it exerted indirect buffering effects through bridging pathways.Gender-specific comparisons revealed that in the male network,physical exercise and health attitude had more prominent positive bridging functions,whereas in the female network,work execution and resistance to temptation played protective roles.After 5000 bootstrap resamples,all centrality indices had stability coefficients above 0.75,indicating a robust and reliable model.These findings identify sleep procrastination and impulse control as precise intervention targets and suggest that stratified strategies should be developed based on gender differences,providing systematic network-based empirical evidence for college health management.

4.1 Overall Network Structure: Dense Self-Control Sub-Module and Sleep Procrastination as the Core Risk Hub

The self-control sub-dimensions formed the densest sub-module, with strong negative partial correlations between impulse control and health habits and between sleep procrastination and resistance to temptation. This aligns with prior evidence that self-control is significantly negatively correlated with sleep procrastination ($r = -0.40$)^[33]. Moderation of entertainment consumption ($z = 1.304$), health habits ($z = 0.693$), and impulse control ($z = 0.583$) showed the highest strength centrality, indicating the strongest direct connections with other nodes, whereas physical exercise had the lowest strength centrality ($z = -1.780$), suggesting weak direct associations and indirect protective pathways^[34]. A survey of 228 Shenzhen University students confirmed that physical exercise improves sleep quality directly and indirectly by alleviating mobile phone addiction^[35]. Sleep procrastination had the largest absolute negative expected influence ($z = -1.716$), occupying the core risk position. Sleep procrastination may reduce nocturnal recovery and prefrontal inhibitory control, co-occurring with lower impulse control, reduced resistance to temptation, and more severe short-video addiction. Sleep problems are the primary health impairment associated with short-video addiction^[1]. In contrast, moderation of entertainment consumption ($z = 1.443$), impulse control ($z = 0.912$), and work execution ($z = 0.507$) showed relatively high positive expected influence, serving as protective forces^[33]. Although physical exercise had weak strength centrality, its bridge expected influence was prominent, implying that simple correlation analyses may underestimate its long-term protective value^[7]. Aerobic exercise may restore self-control resources via prefrontal neuroplasticity, but its effects depend on cross-module transmission through health attitude and impulse control^[34]. Thus, sleep procrastination and impulse control are the most critical risk and protective nodes, respectively, and core targets for regulating short-video addiction.

4.2 Functional Stratification of Core Nodes: Cross-Module Transmission via Bridge Expected Influence

Bridge expected influence identifies nodes connecting different modules; higher values indicate stronger cross-module transmission^[36]. Sleep procrastination had the lowest bridge expected influence, and short-video addiction showed strong negative bridging effects, indicating that both act as key negative bridges transmitting risk from the addiction module to the sleep and self-control modules. Increased sleep procrastination weakens all self-control dimensions and exacerbates short-video addiction, while addictive behaviors deplete impulse control resources, forming a bidirectional reinforcing cross-module risk cycle. Short-video addiction is significantly positively correlated with sleep procrastination ($r = 0.44$), and excessive use affects sleep quality through bedtime delay and self-control^[33]. Emotional factors also transmit risk: among 844 college students, short-video use intensity directly negatively predicted sleep quality and indirectly affected it through loneliness and fear of missing out^[37]. Health attitude and work execution ranked first and second in positive bridge expected influence, showing the strongest cross-module connecting functions. Such nodes often integrate different psychological dimensions^[38]. Health attitude links the cognitive and behavioral modules by shaping long-term health motivation, enhancing health habits and work execution, and indirectly reducing uncontrolled video browsing. Work execution was connected to both self-regulation and risk-related variables; whether changing work execution alters short-video use or sleep procrastination requires intervention

testing. Health cognition has cross-behavioral protective effects^[29]. Using bridge expected influence, this study quantified these cross-module effects, distinguished within-module core nodes from cross-module bridging nodes, and provided targets for stratified interventions.

4.3 Exploratory Gender-Specific Network Heterogeneity: Shared Risk Nodes but Descriptive Differences in Protective Bridging

NCT comparisons revealed commonalities in underlying structure but marked gender differences in positive bridging variables. Sleep procrastination and short-video addiction were shared negative core nodes in both genders. Sleep procrastination and resistance to temptation showed strong negative associations, and both short-video addiction and sleep procrastination exhibited highly negative expected influence. The addiction–sleep procrastination cycle is a common health issue, supporting unified education on sleep management and short-video moderation. In males, physical exercise and health attitude showed prominent cross-module protective functions, with higher bridge expected influence. Males generally participate in sports more frequently and intensely^[25]; exercise may replenish self-control resources and alleviate negative emotions, and male health cognition may more directly affect daily routines and entertainment. Group sports and health cognition education may thus benefit males, consistent with gender-specific exercise intervention findings^[39] and evidence that exercise interventions improve addictive behaviors more in males^{[5][40]}. In females, work execution and resistance to temptation showed stronger bridging associations. Female students may rely on structured study and daily self-regulation to constrain short-video use, while internal moral constraints strengthen resistance to temptation. High neuroticism may amplify negative emotions induced by addiction and sleep procrastination, forming an “emotional depletion–late-night short-video browsing” cycle. The female network showed higher internal connection density among self-regulation and interpersonal variables, extending gender differences from single associations to the whole behavioral network^[24]. Practically, future trials could test whether intervention tailoring based on behavioral profiles or relevant contextual factors improves outcomes; the present findings alone do not justify gender-specific intervention programs: males may prioritize group physical activities and health cognition seminars; females may focus on time management, work execution training, and emotion regulation.

4.4 Theoretical and Practical Implications

Methodologically, this study introduced GGM-based psychological network analysis, addressing limitations of single-mediation and linear regression models in short-video addiction research. It distinguished direct associations from cross-module bridging effects, depicted indirect buffering by physical exercise and health attitude, and enriched multivariable systemic interaction theory. Bootstrap robustness and NCT gender invariance testing provided a standardized framework for health behavior network research. Although network analysis has examined central symptoms of internet addiction and drug addiction^{[41][42]}, it has rarely been applied to the integrated system of short-video addiction, sleep procrastination, and physical exercise. At measurement level, decomposing the Self-Control Scale for

College Students^[30] avoided using only total scores, identified functionally differentiated nodes such as impulse control and work execution, refined stratified associations in the addiction–sleep cycle, and expanded sub-dimension applications^[43]. At group level, the study systematically examined commonalities and heterogeneity between male and female networks, showing that risk nodes are universal while protective bridging variables are gender-differentiated, supplementing gender-difference frameworks in short-video addiction^[24].

4.5 Limitations

This study has several limitations. The cross-sectional design captures only static associations, precluding temporal or causal inference and long-term intervention effects. Future research could use diary methods^[21], longitudinal follow-up, or cross-lagged network analysis with multi-wave data to clarify bidirectional temporal associations between short-video addiction and sleep procrastination^[15]. Convenience sampling from undergraduate institutions, predominantly freshmen and sophomores, excludes vocational and graduate students, limiting generalizability; vocational students' short-video addiction warrants attention^[44]. Self-report measures may introduce social desirability bias; objective indicators such as background short-video usage time and sleep monitoring could improve data quality. Confounding psychological variables (e.g., anxiety, depression, parenting styles) were not included. Anxiety mediates short-video addiction–sleep quality links^[14], and negative emotions show complex network associations with problematic internet use^[39]; future studies should incorporate emotional variables.

5 Conclusion

Using Gaussian graphical model network analysis, this study depicted the cross-sectional association network among physical exercise, short-video addiction, sleep procrastination, health attitude, and five self-control dimensions (impulse control, health habits, resistance to temptation, work execution, and moderation of entertainment consumption) in college students. The self-control submodule showed the densest internal connections. Sleep procrastination had the highest closeness centrality and largest negative expected influence, representing the core risk node, whereas impulse control showed relatively high positive expected influence and betweenness centrality, serving as a protective node. Health attitude and work execution had the most prominent positive cross-module associations. Physical exercise showed weak direct partial correlations but relatively high bridge expected influence, suggesting indirect pathways; sleep procrastination and short-video addiction were closely linked to cross-module risk. Gender-stratified comparisons showed negative expected influence for short-video addiction and sleep procrastination in both networks, but protective cross-module patterns differed: physical exercise and health attitude were stronger in males, while work execution and resistance to temptation were more prominent in females. These findings identify impulse control and sleep procrastination as core nodes and indicate gender-stratified differences in estimated network connectivity. Universities may strengthen self-control training and sleep hygiene education for all students while providing exploratory gender-stratified hypotheses for guidance, offering a system-level reference for may inform hypothesis

generation and the design of future prospective or intervention studies of short-video addiction and sleep procrastination.

Abbreviations

BH

Benjamini-Hochberg

BPS

Sleep Procrastination Scale

EBICglasso

Extended Bayesian Information Criterion graphical least absolute shrinkage and selection operator

GGM

Gaussian graphical model

IRB

Institutional Review Board

NCT

Network Comparison Test

PARS-3

Physical Activity Rating Scale-3

SCS

Self-Control Scale for College Students

SD

standard deviation.

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the Faculty of Psychology, Guangzhou Sport University (IRB number: 2026LCLL-144). All participants were informed of the study details and provided informed consent prior to participation; informed consent was also obtained from their legal guardians.

Consent for publication

Not applicable. The manuscript does not contain identifiable individual data.

Competing interests

The authors declare that they have no competing interests.

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Author Contribution

ML contributed to conceptualization, methodology, investigation, formal analysis, data interpretation, and drafting. CL contributed to study design, data analysis and interpretation, and manuscript revision. HC contributed to conceptualization, supervision, project administration, and manuscript revision. All authors read and approved the final manuscript.

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Data Availability

The raw datasets generated and analysed during the current study are not publicly available due to restrictions on participant privacy, but are available from the corresponding author on reasonable request.

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Figures

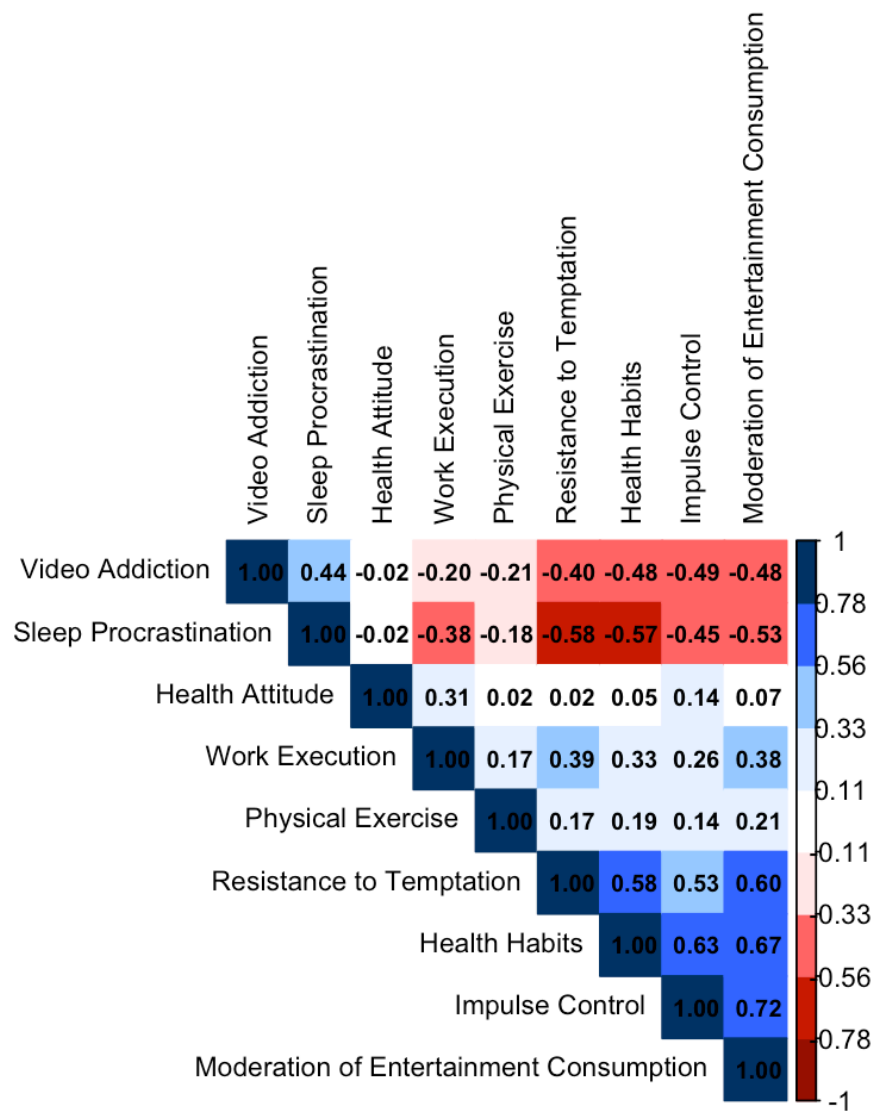


Figure 1

Partial-correlation network among variables.

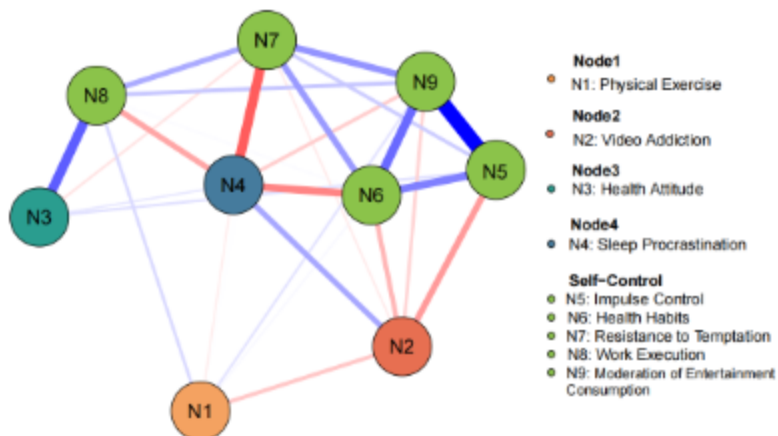


Figure 2

Network structure of physical exercise, short-video addiction, health attitude, sleep procrastination and dimensions of self-control.

Note. N1,Physical Exercise;N2,short-video addiction;N3,Health Attitude;N4,Sleep Procrastination;N5,Impulse Control;N6,Health Habits;N7,Resistance to Temptation;N8,Work Execution;N9,Moderation of Entertainment Consumption

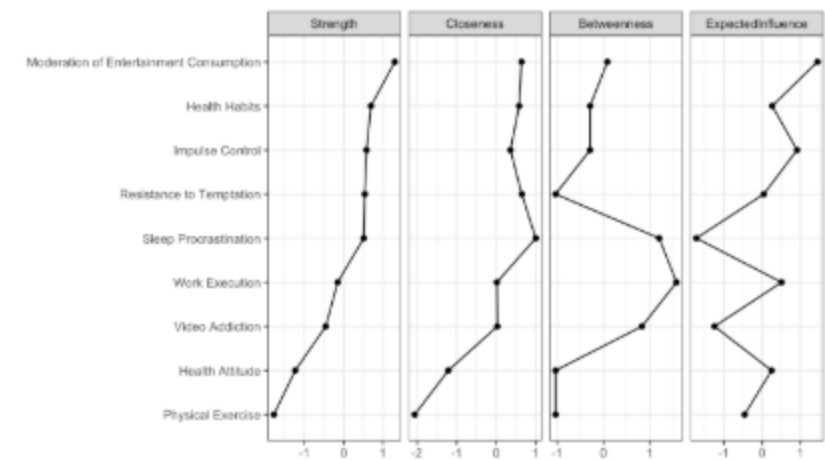


Figure 3

Comparison of strength centrality, closeness centrality, betweenness centrality and expected influence of each node.

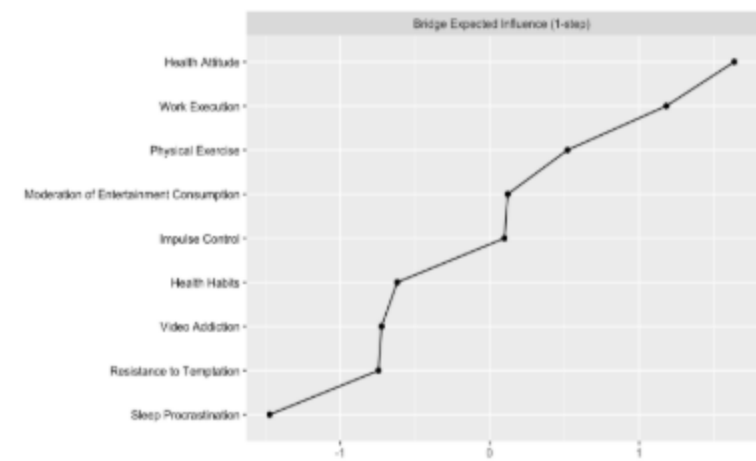


Figure 4

Bridge expected influence.

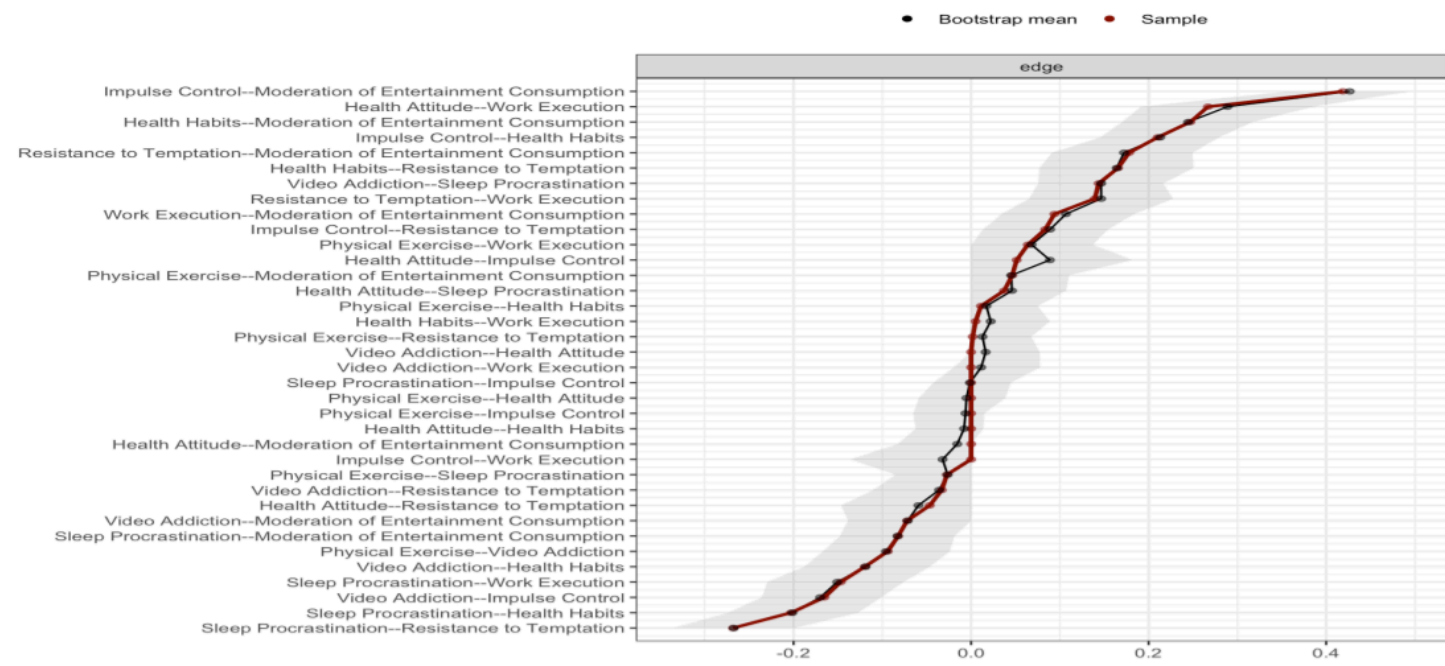


Figure 5

Bootstrap confidence intervals of edge weights.

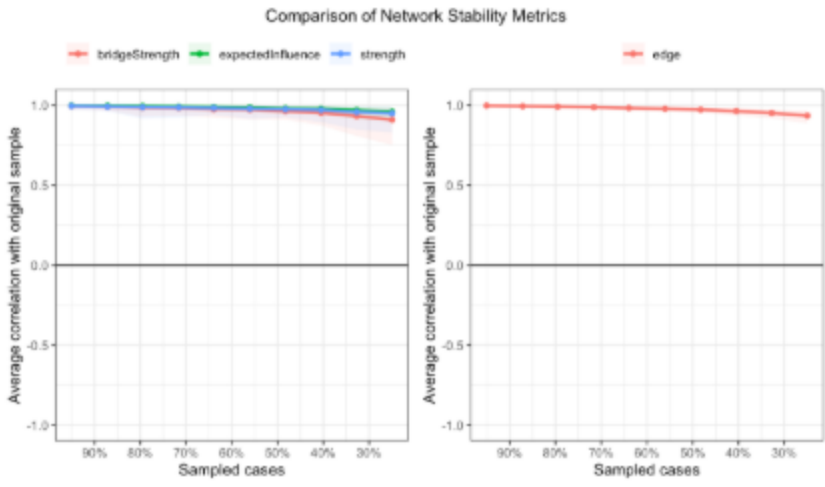


Figure 6

Stability plot of centrality indices.

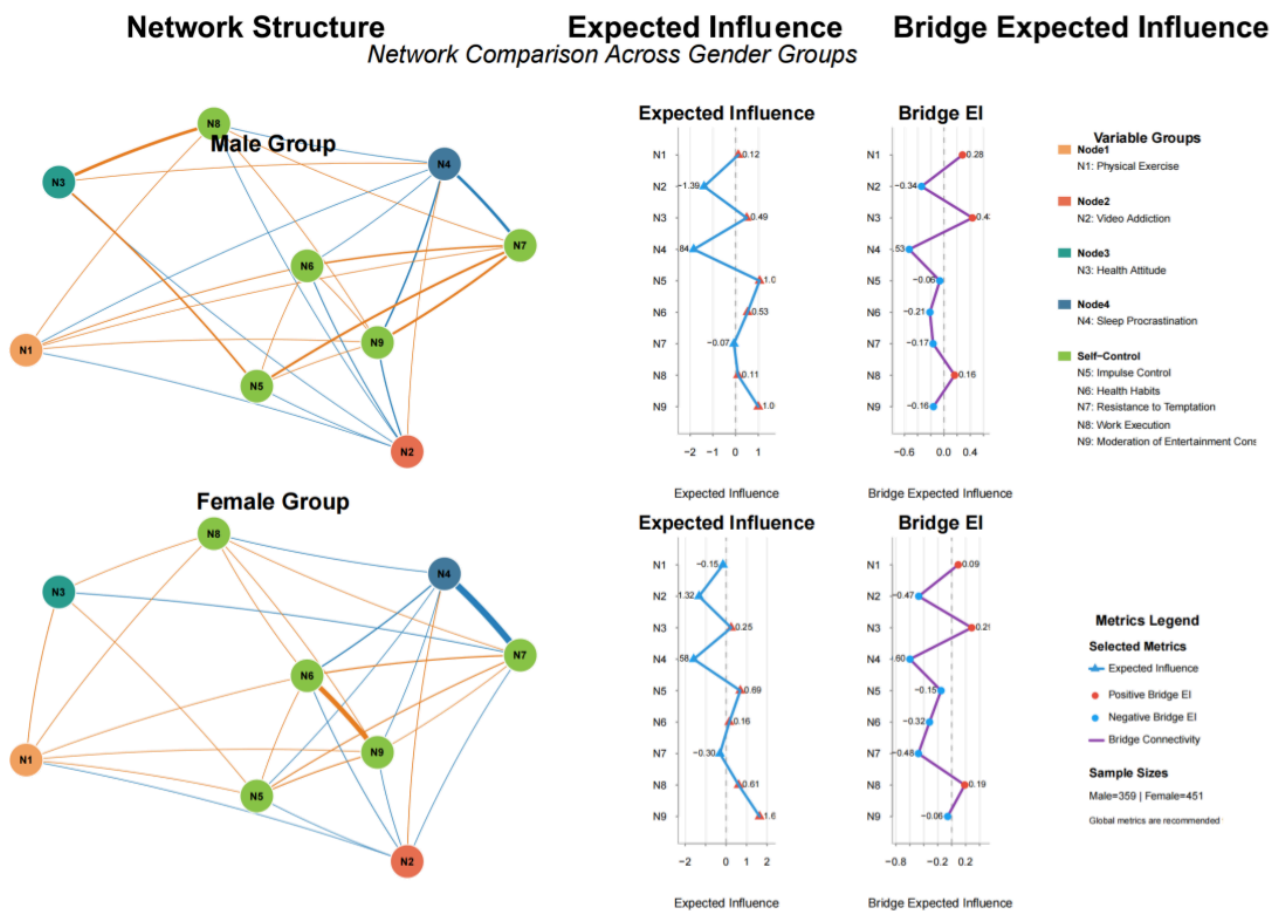


Figure 7

Comparison of network structure, expected influence and bridge expected influence across gender groups.

Note. N1:Physical Exercise;N2:short-video addiction;N3:Health Attitude;N4:Sleep Procrastination;N5:Impulse Control;N6:Health Habits;N7:Resistance to Temptation;N8:Work Execution;N9:Moderation of Entertainment Consumption

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