

医学生压力知觉与焦虑、抑郁症状的双向纵向关联： 一项三波交叉滞后研究

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[摘要] 目的: 压力知觉、焦虑症状和抑郁症状在医学生中可能相互伴随, 但三者的时间顺序及双向纵向关系尚不明确。同时, 传统交叉滞后面板模型(cross-lagged panel model, CLPM)能否反映个体内动态变化, 也需要通过敏感性分析加以检验。本研究旨在分析医学生3次测量中压力知觉、焦虑症状和抑郁症状的变化趋势, 并分析三者之间的双向纵向关联。**方法:** 采用三波纵向追踪设计, 于2025年6月(T1)、9月(T2)和12月(T3)对医学生进行问卷调查, 有效样本量分别为376、361和343例。采用中文版压力知觉量表(Chinese Perceived Stress Scale, CPSS)、广泛性焦虑量表(Generalized Anxiety Disorder Scale-7, GAD-7)和患者健康问卷(Patient Health Questionnaire-9, PHQ-9)分别评估医学生的压力知觉、焦虑症状和抑郁症状。采用线性混合模型分析3个时间点主要变量的变化趋势, 并采用Bonferroni法进行两两比较。采用Pearson相关分析检验变量间相关性。主要分析模型采用三变量CLPM, 将CPSS、GAD-7和PHQ-9同时纳入同一纵向模型, 以检验压力知觉、焦虑症状和抑郁症状之间的双向纵向关联。在三变量CLPM主分析基础上, 构建CPSS-GAD-7和CPSS-PHQ-9二变量CLPM作为补充分析, 以考察压力知觉分别与焦虑症状、抑郁症状之间的纵向关联。进一步采用随机截距交叉滞后面板模型(random-intercept cross-lagged panel model, RI-CLPM)进行敏感性分析, 以检验传统CLPM结果在区分个体间稳定差异与个体内动态变化后的解释边界。纵向模型控制性别和年龄, 并采用稳健最大似然法进行估计。**结果:** 3项指标均存在显著时间效应, 呈T2高于T3、T3高于T1的变化趋势(均 $P<0.001$)。三变量CLPM拟合良好, CPSS、GAD-7和PHQ-9均具有显著纵向稳定性($\beta=0.475\sim 0.701$, 均 $P<0.001$)。在控制性别和年龄并纳入自回归路径及同期相关后, T1和T2压力知觉均与下一时间点焦虑、抑郁症状呈正向、纵向关联(均 $P<0.05$)。在情绪症状对后续压力知觉的纵向关联方面, GAD-7_T1→CPSS_T2、GAD-7_T2→CPSS_T3路径及PHQ-9_T2→CPSS_T3路径均有统计学意义(均 $P<0.05$), 但PHQ-9_T1→CPSS_T2路径无统计学意义($P=0.417$)。此外, GAD-7与PHQ-9之间存在双向纵向预测关系, GAD-7_T1→PHQ-9_T2、PHQ-9_T1→GAD-7_T2、GAD-7_T2→PHQ-9_T3和PHQ-9_T2→GAD-7_T3路径均有统计学意义(均 $P<0.05$)。三变量CLPM中, 除PHQ-9_T1→CPSS_T2路径无统计学意义外, 其余主要交叉滞后路径标准化系数 β 范围为0.082~0.232, 整体属于小效应范围。三变量模型对CPSS_T2、CPSS_T3、GAD-7_T2、GAD-7_T3、PHQ-9_T2和PHQ-9_T3的解释率分别为61.3%、55.8%、59.6%、64.6%、61.7%和51.0%。二变量CLPM结果与三变量模型总体一致。RI-CLPM敏感性分析显示, 三变量RI-CLPM和压力知觉-抑郁症状无等值约束RI-CLPM出现潜变量协方差矩阵非正定; 压力知觉-焦虑症状RI-CLPM获得合格解, 部分交叉滞后路径显著。**结论:** 医学生压力知觉、焦虑症状和抑郁症状之间存在纵向关联。三变量CLPM提示, 在考虑焦虑与抑郁症状相互关联后, 压力知觉与后续情绪症状之间仍存在纵向预测关系, 焦虑与抑郁症状之间也呈现双向纵向预测关系。RI-CLPM敏感性分析提示, 上述结果应主要解释为传统CLPM框架下的纵向关联, 而不宜直接推断为明确的个体内因果效应, 尤其压力知觉与抑郁症状之间的个体内动态关系仍需进一步验证。

[关键词] 医学生; 压力知觉; 焦虑症状; 抑郁症状; 交叉滞后面板模型; 随机截距交叉滞后面板模型; 纵向研究; 敏感性分析

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Bidirectional longitudinal associations of perceived stress with anxiety and depressive symptoms among medical students: A three-wave cross-lagged panel study

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ABSTRACT

Objective: Perceived stress, anxiety symptoms, and depressive symptoms may co-occur among medical students, but their temporal ordering and bidirectional longitudinal relationships remain unclear. Whether conventional cross-lagged panel model (CLPM) adequately reflect within-person dynamic changes also requires examination through sensitivity analyses. This study aims to examine changes in perceived stress, anxiety symptoms, and depressive symptoms across 3 assessments among medical students and to investigate the bidirectional longitudinal associations among these 3 variables.

Methods: A three-wave longitudinal design was used. Medical students were surveyed in June, September, and December 2025, with valid sample sizes of 376, 361, and 343 at T1, T2, and T3, respectively. Perceived stress, anxiety symptoms, and depressive symptoms were assessed using the Chinese Perceived Stress Scale (CPSS), the Generalized Anxiety Disorder Scale-7 (GAD-7), and the Patient Health Questionnaire-9 (PHQ-9), respectively. Linear mixed models were used to examine changes in the main variables across the 3 time points, with Bonferroni correction for pairwise comparisons. Pearson correlation analysis was used to examine correlations among variables. The primary analysis used a three-variable CLPM, in which CPSS, GAD-7, and PHQ-9 were simultaneously included to examine bidirectional longitudinal statistical associations among perceived stress, anxiety symptoms, and depressive symptoms. Based on the primary three-variable CLPM, two-variable CLPMs for CPSS-GAD-7 and CPSS-PHQ-9 were additionally fitted as supplementary analyses to examine the longitudinal associations of perceived stress with anxiety and depressive symptoms separately. Random-intercept cross-lagged panel models (RI-CLPMs) were further fitted as sensitivity analyses to examine the interpretive boundaries of the conventional CLPM findings after distinguishing stable between-person differences from within-person dynamic changes. All longitudinal models were adjusted for sex and age, and parameters were estimated using robust maximum likelihood estimation.

Results: All 3 measures showed significant time effects, with scores being highest at T2, followed by T3 and T1 (all $P < 0.001$). The three-variable CLPM showed good model fit, and CPSS, GAD-7, and PHQ-9 all demonstrated significant longitudinal stability ($\beta = 0.475$ to 0.701 , all $P < 0.001$). After adjustment for sex and age and inclusion of autoregressive paths and within-wave correlations, perceived stress at both T1 and T2 was positively associated with anxiety and depressive symptoms at the subsequent wave (all $P < 0.05$). Anxiety symptoms at T1 and T2 were positively associated with perceived stress at the subsequent wave, and depressive symptoms at T2 were positively associated with

perceived stress at T3 (all $P < 0.05$); however, the path from depressive symptoms at T1 to perceived stress at T2 was not significant ($P = 0.417$). Anxiety and depressive symptoms showed bidirectional positive longitudinal associations across both time intervals (all $P < 0.05$). Except for the nonsignificant path from PHQ-9_T1 to CPSS_T2, the standardized coefficients of the main cross-lagged paths ranged from 0.082 to 0.232, indicating that the associations were generally small in magnitude. The three-variable model explained 61.3%, 55.8%, 59.6%, 64.6%, 61.7%, and 51.0% of the variance in CPSS_T2, CPSS_T3, GAD-7_T2, GAD-7_T3, PHQ-9_T2, and PHQ-9_T3, respectively. The supplementary two-variable CLPMs yielded results generally consistent with those of the three-variable model. In the RI-CLPM sensitivity analyses, both the three-variable RI-CLPM and the unconstrained perceived stress-depressive symptoms RI-CLPM produced non-positive definite latent covariance matrices. In contrast, the unconstrained perceived stress-anxiety symptoms RI-CLPM yielded an admissible solution, with some cross-lagged paths reaching statistical significance.

Conclusion: Perceived stress, anxiety symptoms, and depressive symptoms showed longitudinal associations among medical students. The three-variable CLPM indicated that, after accounting for the interrelations between anxiety and depressive symptoms, perceived stress remained prospectively associated with subsequent anxiety and depressive symptoms, and anxiety and depressive symptoms also showed bidirectional longitudinal associations. RI-CLPM sensitivity analyses suggested that these findings should be interpreted primarily as longitudinal statistical associations within the conventional CLPM framework rather than as evidence of clear within-person causal effects; in particular, the within-person dynamic relationship between perceived stress and depressive symptoms requires further validation.

KEY WORDS

medical students; perceived stress; anxiety symptoms; depressive symptoms; cross-lagged panel model; random-intercept cross-lagged panel model; longitudinal study; sensitivity analysis

医学生作为未来医疗卫生体系的重要人才储备,其心理健康状况不仅关系到个体学习适应和学业发展,也可能对其未来职业发展及医疗服务质量产生长期影响^[1-2]。在当代社会,医学生群体面临的学业压力和社会压力日益增加,心理健康问题尤为突出^[3-4]。既往系统评价和荟萃分析^[4-6]显示,医学生群体中抑郁、焦虑和压力等常见心理问题并不少见,提示该群体心理健康风险需要持续关注。因此,从纵向角度考察医学生压力知觉与情绪症状之间的关系,对于高校心理健康监测和医学教育管理具有现实意义。

压力知觉的概念最早由 Cohen 等^[7-8]提出,指个体对生活中压力源的主观感知和反应。较高水平的压力知觉通常与更多生理和心理负性反应相关,进而增加心理健康问题的风险^[9-10]。对于医学生群体而

言,学业负担、人际关系、临床实习等都是重要的压力源。近期国内研究^[11]显示,医学生临床实习期间心理压力会随实习进程发生变化,提示临床实习阶段可能是压力累积和心理适应的重要时期。国外医学教育研究^[12]也发现,临床见习阶段医学生中抑郁、焦虑和高压力水平较为常见;这些因素与个体的焦虑和抑郁水平密切相关^[13-14]。然而,既往关于医学生压力知觉与焦虑、抑郁症状关系的研究多采用横断面设计,主要揭示变量之间的同期相关或中介关系,难以进一步判断二者在时间进程中的方向性联系^[15-16]。

根据压力-认知评价-应对理论,压力并非单纯由外部事件决定,而是取决于个体对事件威胁性、重要性及自身应对资源的评价^[17-18]。当医学生将学业任务、临床训练或职业发展要求评价为难以控制,或

认为其超出自身可用应对资源时，压力事件更可能转化为焦虑、紧张、无助感和消极认知等情绪反应^[19-21]。近期针对学生群体的研究^[22]亦显示，知觉压力可在教育相关压力与抑郁症状之间发挥重要作用。情绪症状也可能与个体后续压力知觉变化相关^[23-24]。根据资源保存理论，个体具有获得、维持和保护重要资源的基本动机，而资源受威胁、资源丧失或资源投入后未能获得相应回报，均可能诱发压力反应^[25-26]。焦虑和抑郁症状可能伴随学习与认知功能下降、睡眠质量受损以及社会支持感知降低等问题，这些因素均可能消耗个体心理资源，并使其在后续阶段更容易体验到压力^[15, 25, 27]。因此，压力知觉与情绪症状之间可能并非简单的单向关联，而是存在相互关联、共同波动的动态过程。

抑郁和焦虑具有较高共病率^[28]，但其发展路径可能并不完全相同^[29]。抑郁症状通常表现为情绪低落、兴趣减退、精力下降和消极自我评价等^[30]，而焦虑症状则更多表现为过度担忧、紧张不安、警觉性增高及躯体化紧张反应等^[31]。针对大学生群体的研究^[32-34]显示，抑郁症状与焦虑症状较为常见，且二者之间存在明显共现的现象，然而，抑郁和焦虑在临床表现、认知情绪特征及发展路径上并不完全相同，若将二者简单合并为一般情绪困扰，可能掩盖其与压力知觉之间的差异性关联。近期网络分析研究^[35]也提示，焦虑症状和抑郁症状之间虽然联系密切，但不同症状在网络结构中的作用并不完全相同。因此，在医学生群体中，有必要分别考察压力知觉与焦虑症状、压力知觉与抑郁症状之间的纵向关系，以避免将不同情绪症状简单合并解释。同时，若仅将焦虑和抑郁视为压力作用的结果，可能忽视情绪症状本身对后续压力体验的反馈作用。

本研究采用三波纵向追踪设计，以三变量交叉滞后面板模型(cross-lagged panel model, CLPM)作为主要分析模型，考察医学生压力知觉、焦虑症状和抑郁症状之间的双向纵向关联，并通过二变量CLPM和随机截距交叉滞后面板模型(random-intercept cross-lagged panel model, RI-CLPM)进行补充及敏感性分析，以进一步检验研究结果的解释边界。本研究主要探究以下问题：第一，医学生压力知觉、焦虑症状和抑郁症状在3个时间点是否存在显著变化；第二，在同时考虑焦虑和抑郁症状相互影响后，压力知觉是否与后续焦虑和抑郁症状存在纵向关联；第三，焦虑和抑郁症状是否也与后续压力知觉存在反向纵向关联；第四，RI-CLPM敏感性分析在何种程度上提示传统CLPM结果的解释边界。通过上述分析，本研究旨在为医学生心理健康风险识别、压力

管理和情绪症状早期干预提供纵向统计证据。

1 对象与方法

1.1 伦理声明

本研究符合人体试验伦理学标准，已获得中南大学湘雅医院医学伦理委员会的批准(审批号：2025040543)。所有研究对象均签署知情同意书。

1.2 对象

本研究选择医学相关专业在读学生作为研究对象。采用纵向追踪设计，于2025年6月(T1，基线)、9月(T2)、12月(T3)进行问卷调查。纳入标准：1)调查期间为医学相关专业在读学生，包括本科生和研究生；2)能够理解问卷内容并独立完成填写；3)自愿参加研究并签署知情同意书。排除标准：1)问卷填写存在明显逻辑错误、规律性作答或作答时间明显异常者；2)主要研究变量缺失严重、无法纳入统计分析者。

1.3 研究工具

1.3.1 一般情况表

采用自编一般情况表收集研究对象的社会人口学资料和精神健康相关信息，包括性别、年龄、受教育年限、培养层次、既往精神健康相关问题及家族精神疾病史等。

1.3.2 中文版压力知觉量表

中文版压力知觉量表(Chinese Perceived Stress Scale, CPSS)是当前中国使用最广泛的压力知觉测量量表，具备良好的信度和效度^[36]。采用Likert 5级计分法，从“从不”至“总是”分别赋值为1~5分。总分为14~70，得分高低与个体压力知觉水平呈正比。共有14个条目，其中7个为反向计分。本研究中该量表在T1、T2和T3的克龙巴赫 α 系数分别为0.884、0.826、0.866。

1.3.3 广泛性焦虑量表

广泛性焦虑量表(Generalized Anxiety Disorder Scale-7, GAD-7)用于快速有效地评估个体在过去2周内的焦虑症状^[37]，该量表包含7个条目，采用Likert 4级计分法，得分越高，表示焦虑水平越高。评分分为4组：0~4、5~9、10~14、15~21，分别对应正常、轻度、中度和重度焦虑。本研究中该量表在T1、T2和T3的克龙巴赫 α 系数分别为0.917、0.879、0.865。

1.3.4 患者健康问卷

患者健康问卷(Patient Health Questionnaire-9, PHQ-9)用于评估个体的心理健康状态，尤其是抑郁

症状, 信度、效度均较高^[38]。PHQ-9 包含 9 个问题, 采用 Likert 4 级计分法, 范围为 0~27 分。总分越高, 表示抑郁症的严重程度越高。评分分为 5 组: 0~4、5~9、10~14、15~19、20~27, 分别对应正常、轻度、中度、中重度和重度抑郁。本研究中该量表在 T1、T2 和 T3 的克龙巴赫 α 系数分别为 0.850、0.821、0.813。

1.4 统计学处理

采用 SPSS 26.0 和 Mplus 8.3 软件进行统计分析。首先对数据完整性、缺失情况及变量分布特征进行检查。符合或近似符合正态分布的计量资料采用均值 $\pm$ 标准差表示, 不符合正态分布的计量资料采用中位数(第 1 四分位数, 第 3 四分位数)表示; 分类变量采用频数和构成比表示。连续变量的分布情况结合正态性检验、偏度、峰度及直方图进行判断。对于不同时间点主要变量的变化趋势, 采用线性混合模型进行分析, 并采用 Bonferroni 法进行两两比较。变量间相关性采用 Pearson 相关分析。所有统计检验均为双侧检验, 以 $P < 0.05$ 为差异有统计学意义。

采用 Mplus 8.3 构建三波 CLPM。本研究以三变量 CLPM 作为主要纵向分析模型, 将 CPSS、GAD-7 和 PHQ-9 同时纳入同一模型。模型中纳入各变量相邻时间点之间的自回归路径、相邻时间点不同变量之间的交叉滞后路径、T1 同一时间点变量间相关, 以及 T2、T3 同一时间点残差相关。所有模型均将性别和年龄作为协变量纳入, 以控制其对主要变量纵向关系的潜在影响。在三变量 CLPM 主分析基础上, 进一步构建 CPSS-GAD-7 和 CPSS-PHQ-9 二变量 CLPM 作为补充分析, 以考察压力知觉分别与焦虑症状、抑郁症状之间的纵向关联。

为进一步评估传统 CLPM 结果在区分个体间稳定差异与个体内动态变化后的解释边界, 本研究尝试构建 RI-CLPM 作为敏感性分析模型。RI-CLPM 通过为各变量设置随机截距, 将个体间稳定差异与个体内随时间波动部分进行区分。首先构建同时包含 CPSS、GAD-7 和 PHQ-9 的三变量 RI-CLPM。随后分别构建 CPSS-GAD-7 和 CPSS-PHQ-9 二变量 RI-CLPM, 并比较无等值约束和等值约束模型的估计状态及主要路径结果。

鉴于心理症状量表数据可能存在一定非正态分布特征, 模型采用稳健最大似然估计法(robust maximum likelihood estimation, MLR)进行参数估计。对于随访过程中的缺失数据, Mplus 在 MLR 估计框架下采用基于最大似然的可用信息估计方法进行模型估计, 因此 CLPM 和 RI-CLPM 纵向模型纳入分析

的基线样本量为 376 人。该处理通常基于随机缺失(missing at random, MAR)假设, 即在纳入模型的已观测变量、既往测量值及协变量条件下, 缺失概率与未观测结局值无关。由于缺失机制无法仅由观测数据完全验证, 本研究不能完全排除非随机缺失(missing not at random, MNAR)的可能。线性混合模型同样利用所有可用纵向观测数据进行估计。模型拟合优度采用 χ^2 检验、比较拟合指数(comparative fit index, CFI)、Tucker-Lewis 指数(Tucker-Lewis index, TLI)、近似误差均方根(root mean square error of approximation, RMSEA)及标准化均方根残差(standardized root mean square residual, SRMR)进行综合评价。

在正式统计分析前, 采用 Harman 单因子检验评估共同方法偏差。将基线(T1)所有问卷条目纳入未旋转主成分分析, 结果显示, 特征值大于 1 的因子共 5 个, 首个公因子解释的总变异为 38.52%, 低于 40% 的常用判定标准, 提示本研究不存在明显共同方法偏差。此外, 本研究采用三波纵向追踪设计, 不同时间点的数据收集在程序上也有助于降低共同方法偏差对研究结果的影响。

2 结 果

2.1 研究对象的人口学特征及主要变量描述性统计

本研究基线共纳入医学生 376 名, 其中 3 个时间点均完成测量者为 343 名, T2 和 T3 有效随访人数分别为 361 名和 343 名, 有效随访率分别为 96.01% 和 91.22%。基线样本中, 男性 129 名(34.31%), 女性 247 名(65.69%); 年龄中位数为 21.00(20.00, 23.00)岁, 受教育年限中位数为 15.50(14.00, 17.00)年。本科生 271 名(72.07%), 研究生 105 名(27.93%)。少数研究对象自陈既往存在精神健康相关问题, 其中抑郁相关问题 12 名(3.19%)、焦虑相关问题 10 名(2.66%)、强迫相关问题 3 名(0.80%)、双相相关问题 2 名(0.53%)、人格相关问题 1 名(0.27%)、注意缺陷多动相关问题 1 名(0.27%); 有精神疾病家族史者 20 名(5.32%)。上述既往精神健康相关问题来源于研究对象自由填写, 未通过结构化访谈或病历资料进一步核实。

基于各时间点有效样本计算的原始描述性统计结果显示, T1、T2 和 T3 的 CPSS 得分分别为 40.99 ± 8.91 、 44.43 ± 10.06 和 42.21 ± 9.44 , GAD-7 得分分别为 5.11 ± 3.46 、 6.76 ± 3.93 和 5.86 ± 3.96 , PHQ-9 得分分别为 6.14 ± 4.15 、 8.73 ± 4.81 和 6.69 ± 4.54 。

2.2 压力知觉、焦虑和抑郁症状的三波变化趋势

线性混合模型结果显示，压力知觉、焦虑症状和抑郁症状的时间效应均具有统计学意义(均 $P<0.001$ ，表1)。

经Bonferroni法进行两两比较后，CPSS、GAD-7和PHQ-9得分均表现为T2显著高于T1和T3，T3显著高于T1，差异均具有统计学意义(均 $P<0.001$)。总体来看，医学生压力知觉、焦虑症状和抑郁症状均在T2达到较高水平，T3较T2有所下降，但仍高于T1水平(图1)。

2.3 各研究变量的相关分析结果

Pearson相关分析结果(表2)显示，CPSS、GAD-7和PHQ-9在3个时间点之间均呈显著正相关，相关系数范围为0.399~0.760(均 $P<0.001$)。各变量自身在相邻时间点之间的相关性较高，其中CPSS_T1与

CPSS_T2、CPSS_T2与CPSS_T3的相关系数分别为0.758和0.696；GAD-7_T1与GAD-7_T2、GAD-7_T2与GAD-7_T3的相关系数分别为0.710和0.760；PHQ-9_T1与PHQ-9_T2、PHQ-9_T2与PHQ-9_T3的相关系数分别为0.701和0.649，提示压力知觉、焦虑症状和抑郁症状均具有一定时间稳定性。同时，压力知觉与焦虑、抑郁症状在同一时间点及不同时间点之间均呈显著正相关(均 $P<0.001$)。上述结果为进一步开展CLPM分析提供了依据。

2.4 三变量CLPM拟合情况

本研究首先构建三变量CLPM，将CPSS、GAD-7和PHQ-9同时纳入同一模型，并将性别和年龄作为协变量纳入，结果显示，三变量模型拟合良好[$\chi^2(15)=21.363$ ， $P=0.126$ ，RMSEA=0.034，90% CI 0.000~0.064，CFI=0.996，TLI=0.989，SRMR=0.031]。

表1 医学生压力知觉、焦虑和抑郁症状的三波变化趋势分析

Table 1 Three-wave changes in perceived stress, anxiety symptoms, and depressive symptoms among medical students

Variables	T1 estimated marginal mean (95% CI)	T2 estimated marginal mean (95% CI)	T3 estimated marginal mean (95% CI)	Time effect
CPSS scores	40.99(40.02 to 41.96)	44.81(43.83 to 45.79)	42.93(41.94 to 43.92)	$F(2, 701.568)=47.059, P<0.001$
GAD-7 scores	5.11(4.71 to 5.50)	6.96(6.56 to 7.35)	6.23(5.83 to 6.63)	$F(2, 693.740)=70.856, P<0.001$
PHQ-9 scores	6.14(5.67 to 6.60)	8.94(8.47 to 9.41)	7.10(6.62 to 7.58)	$F(2, 693.854)=99.120, P<0.001$

Data are presented as estimated marginal means and 95% CI derived from linear mixed models. Time point was included as a fixed effect, and participant was included as a random effect. Pairwise comparisons were adjusted using the Bonferroni correction. For all 3 measures, pairwise comparisons showed that scores at T2 were significantly higher than those at T1 and T3, and scores at T3 were significantly higher than those at T1, all $P<0.001$. CPSS: Chinese Perceived Stress Scale; GAD-7: Generalized Anxiety Disorder Scale-7; PHQ-9: Patient Health Questionnaire-9. T1, T2, and T3 indicate the first, second, and third survey time points, respectively.

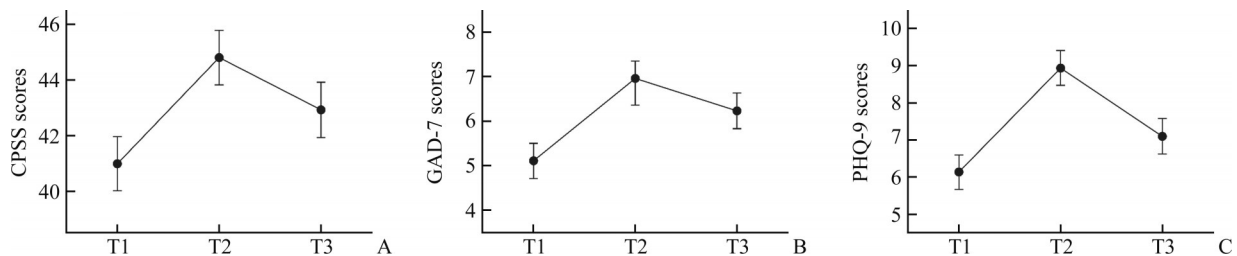


图1 医学生压力知觉、焦虑症状和抑郁症状的三波变化趋势

Figure 1 Three-wave changes in perceived stress, anxiety symptoms, and depressive symptoms among medical students

A: Three-wave change trend of perceived stress (CPSS). B: Three-wave change trend of anxiety symptoms (GAD-7). C: Three-wave change trend of depressive symptoms (PHQ-9). Dots represent estimated marginal means, and error bars represent 95% CI. CPSS: Chinese Perceived Stress Scale; GAD-7: Generalized Anxiety Disorder Scale-7; PHQ-9: Patient Health Questionnaire-9. T1, T2, and T3 indicate the first, second, and third survey time points, respectively.

表2 各研究变量在3个时间点的相关分析结果

Table 2 Correlations among study variables across 3 time points

Variable	CPSS_T1	CPSS_T2	CPSS_T3	GAD-7_T1	GAD-7_T2	GAD-7_T3	PHQ-9_T1	PHQ-9_T2	PHQ-9_T3
CPSS_T1	1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
CPSS_T2	0.758***	1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
CPSS_T3	0.589***	0.696***	1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
GAD-7_T1	0.516***	0.435***	0.399***	1	<0.001	<0.001	<0.001	<0.001	<0.001
GAD-7_T2	0.480***	0.437***	0.476***	0.710***	1	<0.001	<0.001	<0.001	<0.001
GAD-7_T3	0.464***	0.425***	0.433***	0.565***	0.760***	1	<0.001	<0.001	<0.001
PHQ-9_T1	0.529***	0.431***	0.437***	0.651***	0.551***	0.510***	1	<0.001	<0.001
PHQ-9_T2	0.527***	0.470***	0.472***	0.595***	0.550***	0.527***	0.701***	1	<0.001
PHQ-9_T3	0.478***	0.456***	0.459***	0.476***	0.502***	0.412***	0.514***	0.649***	1

Values below the diagonal are Pearson correlation coefficients, values above the diagonal are *P* values, and diagonal values are 1. Correlations represent descriptive zero-order associations. **P*<0.05, ***P*<0.01, ****P*<0.001.

2.5 三变量CLPM主要路径结果

在自回归路径方面, CPSS、GAD-7和PHQ-9在相邻时间点之间均存在显著纵向稳定性。CPSS_T1→CPSS_T2路径($\beta=0.701$, $P<0.001$)、CPSS_T2→CPSS_T3路径($\beta=0.564$, $P<0.001$)、GAD-7_T1→GAD-7_T2路径($\beta=0.569$, $P<0.001$)、GAD-7_T2→GAD-7_T3路径($\beta=0.668$, $P<0.001$)、PHQ-9_T1→PHQ-9_T2路径($\beta=0.475$, $P<0.001$)、PHQ-9_T2→PHQ-9_T3路径($\beta=0.495$, $P<0.001$)均有统计学意义。

在压力知觉对后续情绪症状的纵向关联方面, CPSS_T1→GAD-7_T2路径($\beta=0.159$, 95% *CI* 0.082~0.235, $P<0.001$)、CPSS_T1→PHQ-9_T2路径($\beta=0.204$, 95% *CI* 0.126~0.281, $P<0.001$)、CPSS_T2→GAD-7_T3路径($\beta=0.082$, 95% *CI* 0.015~0.149, $P=0.017$)、CPSS_T2→PHQ-9_T3路径($\beta=0.159$, 95% *CI* 0.071~0.247, $P<0.001$)均有统计学意义。

在情绪症状对后续压力知觉的纵向关联方面, GAD-7_T1→CPSS_T2路径($\beta=0.102$, 95% *CI* 0.016~0.188, $P=0.020$)、GAD-7_T2→CPSS_T3路径($\beta=0.168$, 95% *CI* 0.079~0.256, $P<0.001$)、PHQ-9_T2→CPSS_T3路径($\beta=0.129$, 95% *CI* 0.043~0.216, $P=0.003$)均有统计学意义, 但PHQ-9_T1→CPSS_T2路径无统计学意义($\beta=0.037$, 95% *CI* -0.052~0.127, $P=0.417$)。

此外, 焦虑症状与抑郁症状之间存在显著双向纵向预测关系。GAD-7_T1→PHQ-9_T2路径($\beta=0.232$, 95% *CI* 0.139~0.325, $P<0.001$)、PHQ-9_T1→GAD-7_T2路径($\beta=0.144$, 95% *CI* 0.055~0.232, $P=$

0.001)、GAD-7_T2→PHQ-9_T3路径($\beta=0.172$, 95% *CI* 0.079~0.265, $P<0.001$)、PHQ-9_T2→GAD-7_T3路径($\beta=0.140$, 95% *CI* 0.052~0.227, $P=0.002$)均有统计学意义。模型对CPSS_T2、CPSS_T3、GAD-7_T2、GAD-7_T3、PHQ-9_T2和PHQ-9_T3的解释率分别为61.3%、55.8%、59.6%、64.6%、61.7%和51.0%。从效应量来看, 三变量CLPM中多数显著交叉滞后路径的标准化系数处于0.082~0.204之间, 整体属于小效应范围。其中, CPSS_T2→GAD-7_T3的标准化路径系数为0.082, 虽具有统计学意义, 但效应量较小。三变量CLPM的完整路径图见图2, 详细路径系数见附表1(<https://doi.org/10.57760/sciencedb.45089>)。

2.6 二变量CLPM补充分析

在三变量CLPM主分析基础上, 本研究进一步构建CPSS-GAD-7和CPSS-PHQ-9二变量CLPM作为补充分析, 以考察压力知觉分别与焦虑症状、抑郁症状之间的纵向关联, 结果显示, CPSS-GAD-7模型拟合良好: $\chi^2(8)=14.098$, $P=0.079$, RMSEA=0.045, 90% *CI* 0.000~0.083, CFI=0.995, TLI=0.986, SRMR=0.035。CPSS-PHQ-9模型拟合可接受: $\chi^2(8)=21.031$, $P=0.007$, RMSEA=0.066, 90% *CI* 0.032~0.101, CFI=0.988, TLI=0.967, SRMR=0.043。结合RMSEA、CFI、TLI和SRMR等指标综合判断, CPSS-PHQ-9模型拟合仍处于可接受范围。

交叉滞后路径结果显示, CPSS-GAD-7模型和CPSS-PHQ-9模型的主要路径方向与三变量CLPM总体一致。具体而言, 在CPSS-GAD-7模型中, CPSS

与后续GAD-7之间、GAD-7与后续CPSS之间均存在正向纵向关联；在CPSS-PHQ-9模型中，CPSS与后续PHQ-9之间、PHQ-9与后续CPSS之间也均存在正

向纵向关联。二变量CLPM的模型路径图见图3，详细的交叉滞后路径系数见附表2(<https://doi.org/10.57760/sciencedb.45089>)。

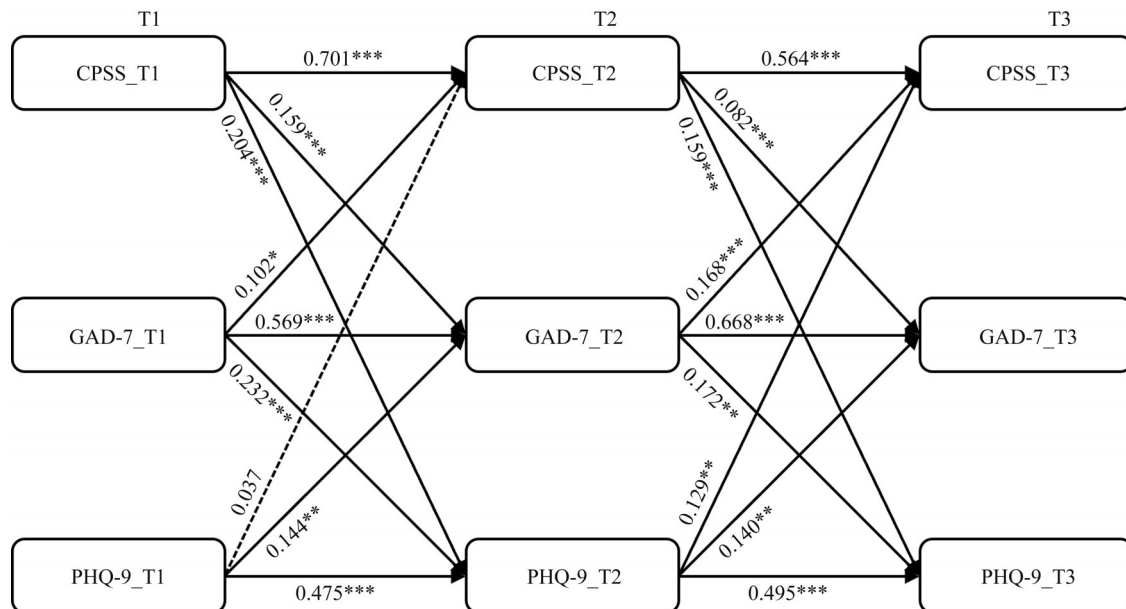


图2 医学生压力知觉、焦虑症状和抑郁症状的三变量交叉滞后面板模型

Figure 2 Three-variable cross-lagged panel model of perceived stress, anxiety symptoms, and depressive symptoms

Solid lines indicate significant paths; the dashed line indicates a nonsignificant path. Values are standardized path coefficients β using the Mplus STDYX standardization (i.e., standardization with respect to the variances of both predictor and outcome variables), adjusted for gender and age. T1, T2, and T3 indicate the first, second, and third survey time points, respectively. * $P<0.05$, ** $P<0.01$, *** $P<0.001$.

2.7 RI-CLPM敏感性分析

为进一步考察传统CLPM结果在区分个体间稳定差异与个体内动态变化后的解释边界，本研究尝试构建RI-CLPM作为敏感性分析模型。各RI-CLPM的拟合指标与估计状态(表3)如下。三变量RI-CLPM的常规拟合指标表面上较好： $\chi^2(15)=15.064$ ， $P=0.447$ ，RMSEA=0.003，90% CI 0.000~0.049，CFI=1.000，TLI=1.000，SRMR=0.017。但模型同时出现潜变量协方差矩阵非正定问题，提示该模型虽在整体拟合指标上表现较好，但参数估计并不可靠，因而不能作为合格模型。进一步检查发现，随机截距之间的标准化相关超过1：压力知觉随机截距与焦虑症状随机截距为1.014，压力知觉随机截距与抑郁症状随机截距为1.115，焦虑症状随机截距与抑郁症状随机截距为1.175，提示压力知觉、焦虑症状和抑郁

症状在个体间稳定水平上高度重叠，三变量RI-CLPM为不合格解。因此，本研究未对该模型的交叉滞后路径进行正式解释。

在二变量RI-CLPM中，CPSS-GAD-7无等值约束模型可正常估计，且未出现潜变量协方差矩阵(latent variable covariance matrix, PSI)非正定问题。该模型显示，CPSS_T1→GAD-7_T2路径($\beta=0.177$ ， $P=0.001$)、GAD-7_T1→CPSS_T2路径($\beta=0.112$ ， $P=0.030$)、GAD-7_T2→CPSS_T3路径($\beta=0.184$ ， $P=0.007$)均有统计学意义；但CPSS_T2→GAD-7_T3路径无统计学意义($\beta=0.076$ ， $P=0.132$)。CPSS-PHQ-9无等值约束RI-CLPM出现PSI非正定问题；进一步采用等值约束模型后，虽未再出现非正定问题，但压力知觉与抑郁症状之间的交叉滞后路径均无统计学意义。

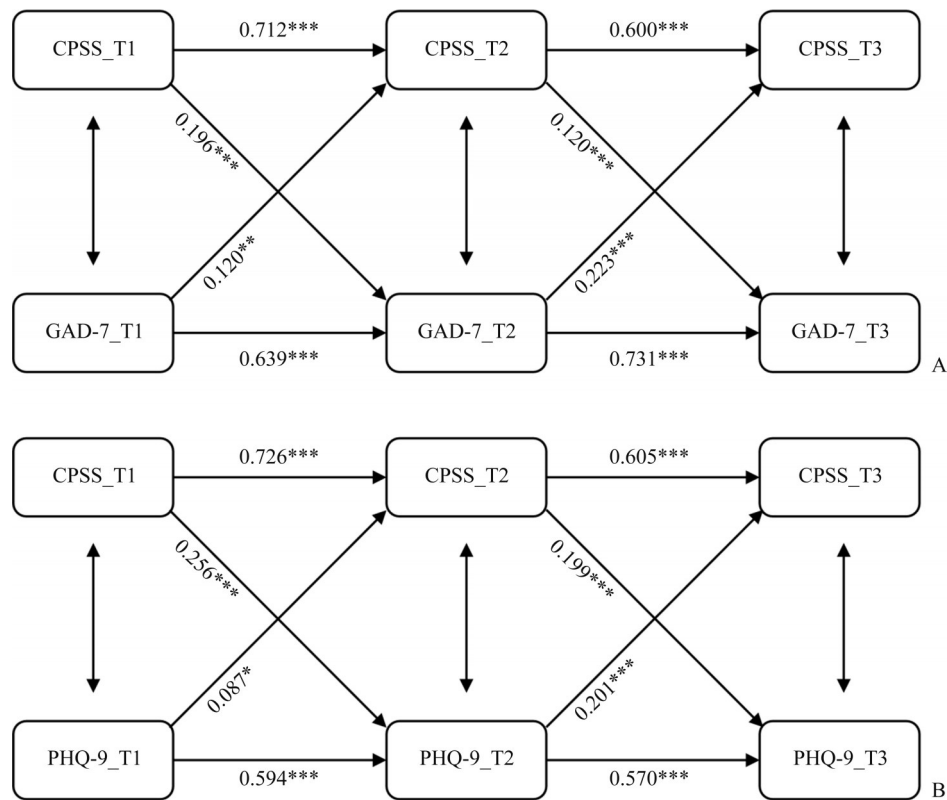


图3 医学生压力知觉与焦虑、抑郁症状的二变量交叉滞后面板模型补充分析

Figure 3 Supplementary two-variable cross-lagged panel models of perceived stress with anxiety and depressive symptoms among medical students

A: Cross-lagged panel model of perceived stress and anxiety symptoms. B: Cross-lagged panel model of perceived stress and depressive symptoms. Values in the figure are standardized path coefficients β adjusted for gender and age. Solid lines indicate statistically significant paths. T1, T2, and T3 indicate the first, second, and third survey time points, respectively. * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

表3 RI-CLPM 敏感性分析的模型拟合指标与估计状态

Table 3 Model fit indices and estimation status of RI-CLPM sensitivity analyses

Model	$\chi^2(df)$	P	RMSEA(90% CI)	CFI	TLI	SRMR
Three-variable RI-CLPM: CPSS, GAD-7, and PHQ-9	15.064(15)	0.447	0.003(0.000 to 0.049)	1.000	1.000	0.017
Two-variable RI-CLPM: CPSS-GAD-7, unconstrained	14.788(9)	0.097	0.041(0.000 to 0.078)	0.995	0.986	0.022
Two-variable RI-CLPM: CPSS-PHQ-9, unconstrained	4.265(9)	0.893	0.000(0.000 to 0.026)	1.000	1.012	0.011
Two-variable RI-CLPM: CPSS-PHQ-9, constrained	32.006(13)	0.002	0.062(0.035 to 0.090)	0.984	0.968	0.060
Two-variable RI-CLPM: CPSS-GAD-7, constrained	32.281(13)	0.002	0.063(0.036 to 0.090)	0.985	0.969	0.061
Model	Estimation status					
Three-variable RI-CLPM: CPSS, GAD-7, and PHQ-9	PSI was not positive definite; random intercept correlations exceeded 1					
Two-variable RI-CLPM: CPSS-GAD-7, unconstrained	Converged normally; no non-positive definite PSI was observed					
Two-variable RI-CLPM: CPSS-PHQ-9, unconstrained	PSI was not positive definite; random intercept correlations exceeded 1					
Two-variable RI-CLPM: CPSS-PHQ-9, constrained	Converged normally; no non-positive definite PSI was observed					
Two-variable RI-CLPM: CPSS-GAD-7, constrained	Converged normally; no non-positive definite PSI was observed					

RI-CLPM: Random-intercept cross-lagged panel model; RMSEA: Root mean square error of approximation; CFI: Comparative fit index; TLI: Tucker-Lewis index; SRMR: Standardized root mean square residual; PSI: Latent variable covariance matrix. The values in parentheses for RMSEA are 90% CI.

3 讨 论

本研究基于三波纵向数据，主要采用三变量CLPM考察医学生压力知觉、焦虑症状和抑郁症状之间的纵向关联，并进一步采用二变量CLPM和RI-CLPM进行补充及敏感性分析。结果显示，压力知觉、焦虑症状和抑郁症状在3个时间点均存在显著变化，整体表现为T1水平最低，T2水平最高，T3较T2有所下降但仍高于T1。三变量CLPM显示，在控制性别、年龄、各变量自身稳定性及同一时间点相关后，压力知觉与后续焦虑和抑郁症状之间存在正向、纵向关联；焦虑症状与后续压力知觉之间在2个相邻时间段均存在正向、纵向关联，抑郁症状与后续压力知觉之间的关联主要体现在T2至T3阶段；焦虑症状与抑郁症状之间也呈现双向、纵向预测关系。RI-CLPM敏感性分析显示，三变量RI-CLPM及CPSS-PHQ-9无等值约束RI-CLPM出现不可容许解，提示CLPM结果不宜进一步外推为稳定的个体内动态效应。因此，本研究主要将相关结果解释为传统CLPM框架下的纵向统计预测关系，而不直接推断为个体内因果效应。上述结果提示，医学生压力知觉与情绪症状之间存在较为复杂的纵向关联。

本研究发现压力知觉、焦虑症状和抑郁症状在三波随访中呈现显著变化。该变化趋势可能与不同调查时间点所处的学业阶段有关。T1调查时间为2025年6月，处于春季学期末期，课程基本进入收尾阶段，考核阶段可能已陆续结束，并且学生经过一个学期的学习后已有一定适应，加之暑期临近可能带来一定恢复预期，因此主观压力知觉相对较低。T2调查时间为2025年9月，接近新学期开始或入学适应阶段，学生可能面临新的课程安排、学习任务重启、人际适应和培养要求变化，压力的不确定性和适应负担增加，因而压力知觉及情绪症状水平较T1明显升高。T3调查时间为2025年12月，处于秋季学期后期，可能接近期末复习、课程考核或考试准备阶段，学业压力仍然存在。但与9月相比，学生对本学期课程节奏和学习要求已有一定了解，因此相关指标较T2有所回落，但仍高于T1水平。一项前瞻性纵向研究^[39]显示，与考核期前相比，医学生在考核期中的压力检出率和耗竭水平均显著升高，提示医学教育中的考核和评价阶段可能是学生心理压力累积的重要时间窗口。由于本研究未直接测量各阶段具体考试安排、课程负荷、临床实践强度及个体生活事件，上述解释仍需谨慎，未来研究可结合学期节律和具体压力事件进一步验证。

本研究观察到压力知觉、焦虑症状和抑郁症状

在相邻时间点之间均存在显著自回归效应，说明这些心理变量具有一定时间稳定性。该结果与既往纵向研究^[40-41]较为一致，即青年学生群体的压力与情绪症状往往具有一定时间延续性，并可能在持续暴露于压力情境时呈现累积风险。对于医学生而言，高负荷课程、持续性考核、科研训练和临床实践要求可能使压力和情绪困扰在一段时间内持续存在。若早期压力和情绪症状未能得到及时识别，其后续心理状态可能继续受到既往状态影响，形成一定的“惯性维持”特征。

三变量CLPM结果显示，压力知觉与后续焦虑和抑郁症状之间存在纵向统计预测关系，提示压力知觉可能是医学生后续情绪症状变化的风险信号之一。压力知觉是指个体对生活情境是否具有不可预测性、不可控制性和负荷过重特征的主观评价，反映其对环境要求与自身应对资源之间关系的感知^[7, 17, 42]。根据压力-认知评价-应对理论，压力反应并非单纯由客观事件决定，而是源于个体对外部要求、事件意义及自身应对资源之间关系的主观评价^[17, 43]。当医学生将课程学习、考试评价、临床训练或职业发展要求评价为难以控制或超出自身资源时，更容易产生紧张、担忧、无助和消极期待等反应，进而增加焦虑和抑郁症状风险。需要指出的是，三变量CLPM中显著交叉滞后路径的标准化系数整体处于小至较小效应范围，尤其CPSS_T2→GAD-7_T3路径的标准化系数仅为0.082。该结果提示，虽然部分路径有统计学意义，但其实际效应有限，不宜将其解释为较强的预测效应。此外，模型对各结局变量的解释率较高，主要可能与各变量较强的自回归路径及同一时间点相关有关，不能将模型整体解释率直接等同于交叉滞后路径效应较强。

本研究同时发现，情绪症状对后续压力知觉的纵向关联并不完全一致。其中，焦虑症状与后续压力知觉在2个相邻时间段均存在关联，而抑郁症状对后续压力知觉的纵向关联主要体现在T2至T3阶段。根据资源保存理论，资源受威胁、资源丧失或资源投入后未能获得相应回报，均可能诱发或加重压力体验^[25-26]。结合医学生群体特点看，抑郁症状可能伴随精力下降、无助感、低控制感和消极归因倾向，可能使学生在面对课程考核、临床训练和职业发展压力时，更容易将困难评价为难以掌控或难以胜任^[20, 44]。焦虑症状则可能通过增强威胁警觉、过度担忧和不确定性感受，使学生对学习表现、临床操作和未来发展形成更高的风险预期，进而放大后续压力体验^[45]。

二变量CLPM补充分析显示，压力知觉分别与

焦虑症状、抑郁症状之间的主要路径方向与三变量模型总体一致,但二变量模型未同时控制焦虑症状与抑郁症状之间的纵向关联,因此主要用于补充说明总体关联,不作为主要结论依据。三变量模型进一步显示,在同时控制焦虑与抑郁症状的相互关联后,压力知觉对后续焦虑和抑郁症状之间的纵向预测关系仍有统计学意义。焦虑症状中的过度担忧、威胁预期和对不确定性的敏感性,可能使医学生在面对课程考核、临床训练或未来职业发展时更容易预期失败或受到负性评价,从而增加无助感、兴趣下降和消极自我评价等抑郁样表现的风险^[46-47]。另一方面,抑郁症状所伴随的精力下降、动机不足、自我效能感降低和低控制感,也可能削弱个体应对课程学习和临床训练要求的信心,使其在面对后续学业或临床任务时更容易产生担忧和焦虑体验^[48]。

需要注意的是,RI-CLPM敏感性分析中出现的潜变量协方差矩阵非正定问题,提示模型参数估计可能存在不稳定,常与潜变量间相关过高、方差估计异常或模型复杂度较高有关。在本研究中,三变量RI-CLPM中随机截距之间的标准化相关均超过1,提示压力知觉、焦虑症状和抑郁症状在个体间稳定水平上高度重叠,使模型难以充分区分个体间稳定差异与个体内动态波动。因此,尽管三变量RI-CLPM的RMSEA、CFI、TLI和SRMR等整体拟合指标较好,其交叉滞后路径仍不宜作实质性解释。CPSS-PHQ-9无等值约束RI-CLPM同样出现PSI非正定问题,等值约束模型虽可正常收敛,但交叉滞后路径无统计学意义,提示压力知觉与抑郁症状之间的个体内动态关系仍需进一步研究验证。值得注意的是,在可获得合格解的CPSS-GAD-7无等值约束RI-CLPM中,部分交叉滞后路径仍达到统计学显著,提示压力知觉与焦虑症状之间观察到的部分纵向关联,可能不完全归因于个体间稳定差异。然而,该证据仅限于CPSS-GAD-7二变量模型,不能外推为三变量CLPM整体结果的稳健性证据。

本研究仍存在一定局限。第一,研究变量主要来源于自评量表,未来可结合多源评估指标加以验证。第二,研究采用3次短期间隔追踪设计,结果更主要反映心理变量在相对短期时间尺度上的动态关联,未来仍需通过更长期纵向研究进一步考察其发展轨迹与长期作用模式。第三,传统CLPM未能区分个体间稳定差异与个体内动态变化。虽然本研究已尝试将RI-CLPM作为敏感性分析,但由于本研究仅包括3个测量时间点,且压力知觉、焦虑症状和抑郁症状在个体间稳定水平上高度相关,三变量RI-CLPM出现潜变量协方差矩阵非正定问题,部分二变

量RI-CLPM结果也存在估计不稳定或路径不显著的情况。因此,RI-CLPM结果主要用于提示传统CLPM结果在个体内动态效应解释层面的边界,尚不足以支持明确的个体内因果机制。第四,本研究存在一定随访流失。基线376人中,T3有效随访343人,累计流失率为8.8%。本研究采用基于最大似然的可用信息估计方法处理缺失数据,该方法主要基于MAR假设,但缺失机制无法完全验证,若失访者与留存者在未观测心理症状水平上存在系统差异,仍可能产生随访偏倚。未来研究需进一步提高随访率并评估缺失机制。第五,虽然本研究以三变量CLPM作为主要分析模型,以同时考察压力知觉、焦虑症状和抑郁症状之间的相互预测关系,但该模型仍属于量表总分层面的纵向模型,不能进一步识别具体压力维度、焦虑症状条目和抑郁症状条目在动态网络中的核心作用。未来研究可在更大样本和更多测量时间点基础上,采用交叉滞后网络模型进一步分析条目层面的定向预测关系,识别医学生心理问题发展过程中的关键症状节点和桥接症状;也可结合潜变量增长模型等方法,进一步考察压力及情绪症状随时间变化的发展轨迹。第六,本研究中多数显著交叉滞后路径的标准化系数较小,提示相关纵向关联的实际效应有限。因此,研究结果更适合用于识别医学生心理健康变化的潜在风险信号,而不宜将单一路径解释为具有较强预测效力的作用关系。第七,样本来源于单一院校医学生群体,结果的外推性仍需在多中心样本中检验。未来研究应在更广泛样本与更综合模型框架下,对压力知觉与情绪症状之间的纵向动态关系进行持续检验。

本研究结果对医学教育和大学生心理健康促进具有一定启示。医学生心理健康工作不应仅关注抑郁、焦虑等症状本身,也可将压力知觉作为心理健康动态监测中的辅助性早期风险信号。对于压力知觉持续较高的学生,即使其尚未达到明显抑郁或焦虑水平,也应及时开展压力管理、应对方式训练和支持资源评估。同时,鉴于焦虑和抑郁症状与后续压力知觉之间也存在反向纵向关联,单纯关注外部压力源可能不足以全面改善压力与情绪症状共同波动的问题。高校和医学院校还应结合心理健康教育、心理咨询转介、学业支持和同伴支持等措施,开展综合性干预。本研究还显示3个时间点主要变量存在显著波动,提示高校心理健康服务应结合学期节点、考试阶段和临床实践阶段开展动态评估。上述发现也与近年来教育部门强调的“预防为主、关口前移”、加强学生心理健康监测和完善预警功能等工作方向相契合,可为医学生群体中心理健康动态监测

和早期干预工作的细化提供参考。

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