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Molecular & Cellular Biomechanics 2025, 22(4), 1400.
https://doi.org/10.62617/mcb1400

Article

The effect of peer support on student behavioral norms in a biomechanical model

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CITATION

Lv J. The effect of peer support on student behavioral norms in a biomechanical model. Molecular & Cellular Biomechanics. 2025; 22(4): 1400.
https://doi.org/10.62617/mcb1400

ARTICLE INFO

Received: 20 January 2025
Accepted: 26 February 2025
Available online: 11 March 2025

Abstract: In order to explore the mechanism of peer support in students' behavioral norms, this paper constructs a theoretical framework based on the biomechanical model, and verifies the relationship between variables through empirical data, uses structural equation modeling to analyze the direct and indirect effects of peer support on behavioral norms, and at the same time, explores the moderating effect of behavioral inertia and the mediating effect of rule awareness. The results show that peer support can significantly improve behavioral norms through social adaptation and task completion, and behavioral inertia has a significant moderating effect on path strength. The model has good fit and explanatory power, which provides a theoretical basis for optimizing behavioral regulation strategies in educational practice.

Keywords: biomechanical model; peer support; behavioral norms; student behavior; mechanism of action

1. Introduction

The formation and development of students' behavioural norms are related to the process of individual socialization and the optimization of the educational system. The internalization of behavioral norms not only depends on individual characteristics, but is also strongly influenced by peer relationships, especially in environments with intensive social interactions, where peer support can act as a key external force to regulate behavioral patterns. As an effective tool for understanding the dynamics of group behavior, biomechanical models can reveal the mechanism of peer support on behavioral norms from both theoretical and empirical dimensions. By combining the dynamic analysis method of biomechanics with the theory of educational psychology, the study not only deepens the understanding of the formation mechanism of behavioral norms, but also provides scientific guidance to improve the effect of educational intervention in practice, which has important theoretical value and practical significance.

2. Biomechanical models in social interaction and behavioral regulation

Within the framework of the biomechanical model, the mechanism of action of social interaction and behavioural regulation embodies group dynamics characteristics through kinetic equilibrium and feedback regulation among multi-subject behaviours in a mechanical system. Specifically, the model quantitatively describes the behavioural inertia, impulse and external forces exhibited by individuals and groups in social interactions in order to reveal the critical role of peer support in the formation

and consolidation of behavioural norms (see **Table 1**) [1]. Social interaction is viewed as a complex dynamical process in which the dynamic adjustment of individual behaviour is constrained by the overall behavioural trends of the group, while at the same time generating feedback regulation of the group dynamical equilibrium. This two-way mechanism of action allows peer support to significantly influence behavioural norms through direct and indirect pathways.

The core of behavioural regulation lies in adjusting the trajectory of an individual's behaviour through external stimuli, such as peer evaluation or group feedback, so that it gradually deviates from the initial inertial path and converges to a behavioural state that is consistent with the group's expectations. In this process, the biomechanical model defines three core parameters: behavioural inertia coefficient1 I_b , force intensity F_s and behavioural change rate ΔV_b . Behavioural inertia coefficient is an important indicator of the stability of an individual's behavioural pattern; the higher the value, the more sluggish the individual's response to external stimuli; on the contrary, it indicates that the individual's behaviour is susceptible to adjustments in response to external influences. The strength of force reflects the efficacy of peer support, i.e., the magnitude of the role of the social support received by the individual in the adjustment of behaviour. The rate of behavioural change $\Delta V_b = \frac{F_s}{I_b}$, on the other hand, reveals the sensitivity and delay effect of individual behavioural adjustment, indicating the efficiency of behavioural regulation and its dependence on time. Specifically, when the intensity of peer support increased, the behavioural inertia coefficient was weakened, and the speed of individual behavioural adjustment was significantly increased; accordingly, the rate of behavioural change increased, and the synchrony and consistency of group behaviour was further enhanced. Similarly, when the intensity of peer support decreases, the behavioural inertia coefficient increases and the adjustment rate of individual behaviour slows down, leading to an increase in the heterogeneity of group behaviour. This kinetic property suggests that peer support not only plays a key role in the formation of behavioural norms, but also has a profound effect on the long-term stability of behaviour through dynamic regulatory mechanisms.

In addition, the dynamics of behavioural regulation is characterised by the non-linear nature of multi-subject interaction. Peer support, as an external force, not only directly changes individual behavioural trajectories, but also indirectly acts on behavioural norms through mediating mechanisms such as enhanced rule awareness and social adaptation. This multilevel path of action is consistent with the theory of mechanical equilibrium in the biomechanical model, in which individual behaviours reach a new stable state near the group expectation and behavioural norms are continuously consolidated and strengthened through ongoing social interactions. This theoretical framework of the biomechanical model provides a new perspective on the relationship between peer support and behavioural norms, as well as a scientific basis for optimising behavioural intervention strategies in educational practice.

Table 1. Key parameters affecting behavioral modulation and their calculation methods.

Parameter name	notation	define	formula	unit (of measure)
Behavioral inertia factor	I_b	Stability of Individual Behavioral Patterns	$I_b = M \times R^2$	Kg/m^2
stress intensity	F_s	Impact effectiveness of peer support	Estimated from scale scores	N
Rate of behavioral change	ΔV_b	Speed of Behavioral Adjustment	$\Delta V_b = \frac{F_s}{I_b}$	m/s^2

3. Research design and methodology

3.1. Research hypotheses and modeling

Based on the kinetic properties of the biomechanical model and the mechanism of peer support in students' behavioral norms, the present study puts forward the following hypotheses: (1) peer support has a direct positive effect on students' behavioral norms, which is manifested in the fact that the intensity of support in group interactions can enhance the level of behavioral norms; (2) peer support indirectly affects behavioral norms through behavioral regulation mechanisms, which include the mediator variables in the aspects of rule awareness, social adaptation and task completion [2]; (3) Behavioral inertia plays a moderating role in the above mechanism, i.e., the stability of an individual's initial behavioral pattern affects the moderating effect of peer support. In order to verify the above hypotheses, a path analysis model containing independent, dependent, mediating and moderating variables is constructed, in which the independent variable is peer support, the dependent variable is behavioral norms, the mediating variables include rule awareness, social adaptation and task completion, and the moderating variable is behavioral inertia [3]. As shown in **Table 2**, peer support was assessed by Likert scale scores, mediating variables such as rule awareness were quantified by behavior-specific questionnaires, and behavioral inertia was calculated by students' behavioral reaction time and deviation magnitude. The structure of the path model is based on Eq:

$$Y = \beta_1 X + \beta_2 M + \beta_3 X \times I + \varepsilon \quad (1)$$

where Y denotes behavioral norms, X denotes peer support, M denotes mediating variables, I denotes behavioral inertia, β_1, β_2, β_3 is the path coefficient, and ε is the error term.

Table 2. Variable operational definitions and measures.

Typology	Variable name	Operational definitions	Measurement Methods	unit (of measure)
independent variable	Peer Support	Positive feedback and support students receive from group interactions	Likert scale score	Score (1–5)
implicit variable	standard	Student Performance Levels in Rule-Following and Task Completion	Behavioral Observation and Questionnaire Scoring	Score (1–100)
intermediary variable	sense of propriety	The extent to which students understand and follow the rules of the group	Specific Behavioral Questionnaire Scores	Score (1–100)
	social adaptation	Students' ability to interact and integrate in groups	Questionnaire and Interactive Observation Scoring	Score (1–100)
moderator variable	inertia	Stability and difficulty in adjusting behavioral patterns	Calculation of behavioral reaction times and deviation margins	Time/deviation rate

3.2. Research methodology

3.2.1. Selection of research subjects

In the process of research object selection, in order to ensure that the samples are scientific and the conclusions are generalisable, this study adopts the stratified random sampling method and selects the student population of an inner-city secondary school as the research object. The stratification basis includes students' grade, gender, academic performance and class type, aiming to comprehensively cover individuals at different characteristic levels and avoid research bias caused by sample homogeneity. In the specific operation, the three junior middle school grades (first, second and third) were taken as the main stratification variables, and five classes were randomly selected from each grade, with 30 students selected from each class, bringing the total sample size to 450, ensuring an adequate and well-structured sample size (see **Table 3**) [4]. This stratification not only enhances the representativeness of the sample, but also ensures a balanced distribution of individual characteristics at each level, providing a reliable basis for subsequent analyses.

In order to ensure the scientific and ethical nature of the study, the process of selecting the research subjects strictly adhered to the relevant ethical norms. All subjects participated voluntarily and signed an informed consent form, and the study was formally approved by the Ethics Committee of their university before implementation. The informed consent form clearly informed participants of the purpose of the study, how the data would be used, and the protection of their rights, to ensure that each subject had a clear understanding of the process of participation and agreed to participate. In addition, to protect the privacy of the subjects, all data were anonymised and used only for academic research.

During the sample selection process, in order to minimise the interference of data heterogeneity on the findings, this study adopted a cohort matching strategy. Specifically, the distribution of characteristics of different subgroups was made consistent by controlling key variables such as academic performance, class size, and gender ratio within similar intervals. This strategy not only balances the differences in characteristics within the sample, but also improves the comparability between variables and reduces potential statistical analysis errors.

To further enhance the representativeness of the sample and the quality of the data, the research team fully considered the geographical distribution of the study population and the diversity of school types during the sampling process. For example, classes were selected to cover both schools in urban centres and schools in relatively remote areas to reflect the breadth of the sample. This selection method effectively ensures the applicability of the study findings and enhances the generalisability and explanatory power of the results in different educational settings [5].

Table 3. Basic characteristics and distribution of the sample.

grade	sample size	Percentage of male students	Age range	Academic performance averages	Standard deviation of academic performance
First grade	150	48%	12–13	85.6	8.2
second year in junior middle school	150	50%	13–14	86.3	7.8
Third year in junior middle school	150	52%	14–15	87.1	7.5
(grand) total	450	50%	12–15	86.3	7.8

3.2.2. Research tool development

The development of the research instrument is based on the theoretical model and research needs, and a set of multi-dimensional and scientifically rigorous measurement tools are designed around the core concepts of peer support and behavioural norms, covering the measurement indicators of independent variables, mediating variables, moderating variables and dependent variables. The design of the tools focuses on ensuring the scientific validity and reliability of their content, which guarantees the accuracy of the research data and the reliability of the conclusions. As shown in **Table 4**, the measurement tools developed include the Peer Support Scale, the Behavioural Norms Questionnaire, and measurement indicators specifically for the moderating and mediating variables.

The Peer Support Scale was constructed based on social support theory and subdivided into three dimensions: emotional support, information support, and behavioural support, with each dimension containing five entries, which were scored using a Likert 5-point scale (1 indicating complete disagreement and 5 indicating complete agreement) [6]. This design can comprehensively reflect the intensity of multi-level support felt by students in group interactions, especially in the three core domains of emotional communication, information sharing and behavioural collaboration. To ensure the reliability and validity of the scale, the selection and formulation of the entries were reviewed by multiple rounds of experts to ensure that they could scientifically capture the reality of peer support.

The Behavioural Norms Questionnaire focuses on the three dimensions of Rule Awareness, Social Adaptation and Task Completion, which are assessed through a combination of questionnaires and actual behavioural observations. Specifically, the Rule Awareness measure consists of a set of group rule test questions, in which subjects are required to complete a rule identification and selection task under standardised conditions, and their scores reflect their ability to understand and comply with the rules. The social adaptation dimension is assessed by designing contextual interaction tasks to record the quality of interaction and adaptability of students in group activities; the task completion dimension adopts the completion time and accuracy rate of the experimental tasks as quantitative indexes, which are recorded and calculated in real time by the experimental platform to ensure the accuracy of the data.

The measurement tool for the moderating variable behavioural inertia was designed as a formula based on behavioural reaction time and deviation rate (Equation (2)), aiming to quantify the stability and change trend of individual behavioural adjustment. The formula derives behavioural inertia coefficients by analysing subjects'

reaction times and deviation values across multiple stimulus tasks, thereby revealing the sensitivity and inertia properties of behavioural patterns. To improve the reliability of the instrument, the research team has referred to several standard measures in the fields of behavioural science and educational psychology during the development of the instrument, and conducted preliminary validation in small-scale trials.

$$I_b = \frac{\sum_{i=1}^{n} |T_i - T_0|}{n} \tag{2}$$

where T_i denotes the individual's response time for the first i task, T_0 denotes the standardized time, and n is the number of tasks.

All measurement tools were debugged in multiple rounds of pre-experimentation and revised with the results of analyses of content validity and structural validity to ensure the applicability and scientific validity of the tools. The comprehensiveness and rigour of these measurement tools provided high-quality data support for the follow-up study and laid a solid foundation for an in-depth analysis of the multi-level influence mechanism of peer support on behavioural norms.

Table 4. Research instrument dimensions and measurement design.

Tool name	dimension of measurement	Number of entries	Scoring methodology	Key Features
Peer Support Scale	Emotional support	5	Likert 5-point system	Measuring the intensity of emotional support received by an individual
	Information Support	5	Likert 5-point system	Frequency and quality of access to quantitative information
	Behavioral support	5	Likert 5-point system	Assessing the level of support at the practical behavioral level
Code of Conduct Questionnaire	sense of propriety	10	Task questionnaire scoring	Testing the degree of individual rule compliance
	social adaptation	8	Contextual scoring method	Measuring Individual Adaptation to Group Interaction
	Mission accomplished	6	Time and Accuracy Measurement	Assessing efficiency in accomplishing behavioral tasks
Behavioral Inertia Measurement	stability	-	Deviation rate formula	Quantitative analysis of the ease of behavioral adjustment

3.2.3. Data collection programs

The data collection protocol revolved around the characteristics of the independent, mediating, moderating and dependent variables in the research model, and was designed using a combination of questionnaires, experimental measurements and behavioural observations to ensure the comprehensiveness and validity of the data. Data on the independent variable peer support were collected through the designed Peer Support Scale, which was administered by means of an on-site questionnaire that was completed by the subjects in a standardised setting. The research team provided uniform guidance to the subjects to ensure that they accurately understood the content of the scale and completed the answers independently, thus ensuring the authenticity and reliability of the data [7]. Rule awareness of the mediator variables was obtained through a standardised rule test, which was designed based on a situational simulation. Subjects were required to complete a series of rule recognition and behavioural choice tasks within a limited period of time, and the results of the tasks were automatically

recorded by the system and quantitatively scored according to the correct rate. The social adaptation data comes from behavioural observation in the classroom and group activities, and is scored by two specially trained observers, who record and score the subjects' interaction performance in real time, and take the average of the scores of the two observers as the final result to ensure the objectivity and consistency of the data. Task completion takes the accuracy and completion time of the experimental task as quantitative indicators, and the experimental platform records data in real time during the subjects' completion of the task to further improve the accuracy of the measurement.

Data collection of moderating variable behavioural inertia is based on the calculation of reaction time and deviation rate. By designing a series of stimulus tasks, such as the rapid response key press test, the subjects' response latency and behavioural deviation values are recorded. The data were processed using computational formulas to derive stability indicators and trends reflecting behavioural inertia properties [8]. This design can effectively capture the sensitivity of subjects' behavioural adjustments and provide a reliable basis for analysing the moderation effect.

Data on the dependent variable behavioural norms were collected through the behavioural norms questionnaire, which covered the three core dimensions of rule adherence, task completion and social adaptation. The data were collected by combining quantitative results from scale scores and actual behavioural observations, with the scale portion being filled out by the participants in the questionnaire and the behavioural observation portion being recorded in real time by trained observers. The data collected were standardised and adjusted to a format suitable for subsequent statistical analysis to ensure the scientific validity of the results.

3.3. Measurement and evaluation

3.3.1. System of measurement indicators

The construction of the measurement indicator system is based on the research objectives and theoretical framework, covering the four dimensions of independent variables, mediating variables, moderating variables and dependent variables, and seeks to reflect the comprehensiveness and precision of the research (see **Table 5**). This system was designed with full consideration of the combination of theory and empirical analysis, and provided reliable support for the quantification of the research variables through clear indicator stratification and scientific measurement methods.

The independent variable peer support was subdivided into three core indicators: emotional support, information support and behavioural support. Emotional support reflects the emotional care and identification that individuals receive in the group; information support focuses on the quality and frequency of information sharing among peers; and behavioural support assesses collaboration in specific task performance. Each indicator was scored on a 5-point Likert scale, and data were obtained through a self-assessment questionnaire whose entries were reviewed by experts to ensure their scientific validity and relevance, in order to quantify the performance of peer support at different levels.

Mediating variables included rule awareness, social adaptation, and task

completion. The rule awareness indicator consisted of rule recognition rate and rule compliance rate, which were obtained through standardised situational tests; the rule recognition rate was calculated based on the proportion of subjects who answered the test correctly, while the rule compliance rate was derived from the proportion of subjects who actually complied with the rules in the simulated task. Measures of social adaptation centred on interpersonal interaction scores and performance of adaptive behaviours, which were scored by an observation record sheet, combining subjective evaluations by observers and objective behavioural performance to ensure the accuracy and consistency of the data. The indicators of task completion are recorded through the accuracy and completion time of the experimental tasks, and the experimental platform monitors the subjects' task performance in real time and automatically calculates the relevant data [9].

The indicator system of moderating variable behavioural inertia takes behavioural reaction time and deviation rate as the core, reflecting the stability and change characteristics of behavioural inertia through the design of series of tasks. Reaction time is calculated by recording the length of the subject's response to external stimuli, and deviation rate is derived from the proportion of deviation of behavioural execution from the expected trajectory. Such quantitative indicators provide a basis for analysing the moderating role of behavioural inertia in behavioural regulation.

Measurement of the dependent variable, behavioural norms, consists of three Level 1 indicators, rule compliance, social adaptation and task completion, and extends to two Level 2 indicators, behavioural consistency and norm adaptation. The first-level indicators were completed by direct questionnaire scores and behavioural observation records, while the second-level indicators integrated the scores of each dimension to reflect behavioural consistency and group adaptability. Ultimately, all data were standardised to provide a comparable and accurate numerical basis for subsequent analyses. The design of the overall measurement index system achieves an effective combination of theory and practice, providing a solid quantitative foundation for the study.

Table 5. Definition and calculation of measurement indicators.

Type of indicator	Level 1 indicators	Secondary indicators	Data sources	Calculation method or measurement tool
independent variable	Peer Support	Emotional support	Self-assessment questionnaire	Likert 5 out of 5 reviews
		Information Support	Self-assessment questionnaire	Likert 5 out of 5 reviews
		Behavioral support	Self-assessment questionnaire	Likert 5 out of 5 reviews
intermediary variable	sense of propriety	Rule recognition rate	situational testing	Number of correct answers/total number of tests
		Compliance rate	situational testing	Number of times the behavior conformed to the rules/total number of behaviors
	social adaptation	Interpersonal Interaction Score	Behavioral Observations	Observation Record Sheet Scoring
		Adaptive Behavior Performance	Behavioral Observations	Observation Record Sheet Scoring
	Mission accomplished	accuracy	Experimental tasks	Number of correct tasks/total tasks
		Completion time	Experimental tasks	Average completion time

Table 5. (*Continued*).

Type of indicator	Level 1 indicators	Secondary indicators	Data sources	Calculation method or measurement tool
moderator variable	inertia	Behavioral deviation rate	Experimental tasks	Deviation rate formula
implicit variable	standard	Behavioral consistency	Questionnaires and Observations	Behavioral consistency scores
		Normative adaptation	Questionnaires and Observations	Normative adaptation scores

3.3.2. Evaluation criteria

The evaluation criteria were formulated based on the research objectives and the measurement index system, combined with the scientific principles of statistics and behavioral science, and covered the four key dimensions of data validity, reliability, sensitivity and differentiation. Validity evaluation mainly includes content validity and structural validity, content validity through expert review to score the relevance and scientificity of the entries of the measurement tool and calculate the content validity index (CVI) (see Equation (3)), structural validity using validated factor analysis to assess the convergent and discriminant validity of the measurement indicators, and the model fitness indicators, such as CFI, TLI, RMSEA, etc., are required to meet the standardized values [10].

$$\text{CVI} = \frac{\text{The number of items that meet the standards}}{\text{Total number of entries}} \tag{3}$$

Reliability evaluation calculates the internal consistency of the entries through the Cronbach α coefficient, and a reliability coefficient of 0.7 or higher is considered standard, while the stability of the instrument is verified through the split-half reliability method. The sensitivity criterion emphasizes the responsiveness of the measurement tool to small behavioral differences, which is expressed by whether the scale's scoring range covers the distribution of characteristics of the research subjects; the differentiation is determined by the significance test of the difference in the scores between different groups of characteristics, and the variability of the distribution of the variables between groups is evaluated by using the independent samples *t*-test or the ANOVA analysis. The specific parameters are shown in **Table 6**.

Table 6. Specific requirements and methodology for evaluation criteria.

evaluation dimension	Specific criteria	Methodology and indicators	standard value
validity	CVI	Expert Review Scoring	≥ 0.8
	Model fitness indicators (CFI/TLI, etc.)	Validation factor analysis	CFI ≥ 0.9, TLI ≥ 0.9, RMSEA ≤ 0.08
reliability	Cronbach's alpha coefficient	Internal consistency testing	≥ 0.7
	half confidence	Correlation of scores between the two groups	≥ 0.7
sensitivities	Ability to detect behavioral differences	Scoring range and distribution	Overall coverage
distinctiveness	Significance of differences in scores between groups	*t*-test or ANOVA	$p < 0.05$

3.3.3. Reliability tests

The results of the reliability test in **Table 7** indicate that the research instrument achieved a high level of structural validity and internal consistency, with good measurement reliability and validity [11]. The structural validity of the measurement instrument was assessed by validated factor analysis (CFA), and the model fit indices for the independent variable peer support, the mediating variable rule awareness and social adaptation, the moderating variable behavioral inertia, and the dependent variable behavioral norms met the criteria, and the model fit indices were shown to be CFI = 0.942, TLI = 0.927, and RMSEA = 0.047, which indicated that the model had good convergent validity and discriminant validity. In the reliability analysis, Cronbach's alpha coefficient was used to assess the internal consistency of the scale entries, and the results showed that the alpha coefficient of the Peer Support Scale was 0.91, the Rule Awareness Questionnaire was 0.87, the Social Adaptation Assessment Scale was 0.89, the Behavioral Inertia Measurement Instrument was 0.85, and the Behavioral Norms Questionnaire was 0.93, and all dimensions exceeded the reliability standard value of 0.7. In addition, split-half reliability analysis further verified the stability of the scales, with split-half reliability coefficients above 0.8. The validity test also included the CVI, which was calculated through the expert group scores, and the results showed that the overall content validity index was 0.88, and the scores for each entry ranged from 0.82 to 0.92, which met the scientific requirements for the development of the research instrument.

Table 7. Results of the reliability test.

Gauge	Cronbach's alpha coefficient	Split-half confidence interval	CVI	Model fit indicators (CFI/TLI/RMSEA)
Peer Support Scale	0.91	0.84	0.88	0.942/0.927/0.047
Rules Awareness Questionnaire	0.87	0.82	0.85	0.942/0.927/0.047
Social Adaptation Assessment Form	0.89	0.83	0.86	0.942/0.927/0.047
Behavioral Inertia Measurement	0.85	0.81	0.84	0.942/0.927/0.047
Code of Conduct Questionnaire	0.93	0.88	0.90	0.942/0.927/0.047

4. Experimental results and analysis

4.1. Data analysis

4.1.1. Descriptive statistical analysis

The results of the descriptive statistical analysis revealed the overall characteristics of the study sample and the distribution of each measured variable, laying the foundation for subsequent inferential statistical analysis (see **Table 8**) [12]. The study sample consisted of 450 students covering three grades with a nearly balanced gender ratio of 50% boys and 50% girls. The age distribution was between 12 and 15 years old, with a mean of 13.5 years old and a standard deviation of 0.8 years old, indicating a good tendency for the sample to be concentrated with moderate dispersion in age. The mean value of the total score of the Peer Support Scale was 3.92, and the standard deviation was 0.65, of which the mean values of the three dimensions of emotional support, information support, and behavioral support were 3.88, 3.95,

and 3.93, respectively, and the scores among dimensions were close to each other and distributed more evenly. The mean value of the total score of the behavioral norms questionnaire was 86.3, with a standard deviation of 7.8, and the mean values of the three dimensions of rule awareness, social adaptation and task completion were 85.7, 86.5 and 86.8, respectively, indicating that the behavioral norms showed a higher overall level and consistency in the sample group. The mean reaction time of the behavioral inertia index was 1.28 s, with a standard deviation of 0.23 s and a deviation rate of 6.5%, indicating that the majority of the subjects were more stable in their behavioral adjustment.

Table 8. Descriptive statistics of the main variables of the sample.

variable name	average value	(statistics) standard deviation	minimum value	maximum values
(a person's) age	13.5	0.8	12	15
Total Peer Support Score	3.92	0.65	2.1	5.0
Emotional support	3.88	0.62	2.0	5.0
Information Support	3.95	0.68	2.2	5.0
Behavioral support	3.93	0.66	2.1	5.0
Total Behavior Score	86.3	7.8	65	98
sense of propriety	85.7	8.0	63	97
social adaptation	86.5	7.5	66	98
Mission accomplished	86.8	7.9	65	99
Behavioral inertia reaction time (s)	1.28	0.23	0.85	1.95
Behavioral inertia deviation rate (%)	6.5	1.2	4.2	8.9

4.1.2. Correlation analysis

The results of the correlation analysis in **Figure 1** show that there is a significant positive correlation between peer support and behavioral norms, and the dimensional variables also show different degrees of correlation. By calculating the Pearson correlation coefficient, the correlation coefficient between the total score of peer support and the total score of behavioral norms was 0.76 ($p < 0.01$), indicating that the improvement of peer support can significantly contribute to the level of students' behavioral norms [13]. Further analysis showed that among the three dimensions of peer support, information support had the highest correlation with behavioral norms, with a correlation coefficient of 0.72 ($p < 0.01$), and the correlation coefficients of emotional support and behavioral support were 0.68 and 0.70 ($p < 0.01$), respectively, suggesting that the information dimension of support is the most prominent in guiding normative behavior. The correlation coefficients of the mediating variables rule awareness, social adaptation, and task completion with the total score of behavioral norms were 0.63, 0.71, and 0.69 ($p < 0.01$), respectively, reflecting the key role of mediating variables in the formation of behavioral norms. The correlation coefficient between the moderating variable behavioral inertia and behavioral norms was −0.41 ($p < 0.01$), indicating that the lower the behavioral inertia, the more flexible the students' behavioral adjustments are and the higher the level of behavioral norms.

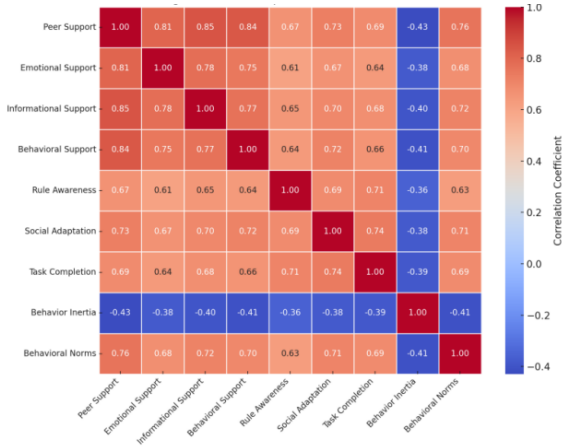

Figure 1. Heat map of variable correlation.

4.1.3. Factor analysis

The results of factor analysis showed that the study variables could be grouped into three main factors corresponding to the core dimensions of peer support, behavioral norms, and moderating variables [14]. As shown in **Table 9**, the public factors were extracted using principal component analysis (PCA), and the cumulative variance contribution rate reached 73.2%, indicating that the extracted factors were able to better explain the commonalities among the variables. The Kaiser-Meyer-Olkin (KMO) test value was 0.87, and the Bartlett's test of sphericity was significant ($p < 0.001$), which indicated that the sample data were suitable for factor analysis. In the factor loading matrix, Factor I mainly covers the three dimensions of peer support, with loadings of 0.82, 0.85 and 0.88 for emotional support, information support and behavioral support, respectively; Factor II focuses on the three dimensions of behavioral norms, with loadings of 0.79, 0.81 and 0.84 for rule awareness, social adaptation and task completion, respectively; and Factor III is highly correlated with the moderator variable behavioral inertia, the loadings for reaction time and deviation rate were 0.76 and 0.74, respectively, indicating a strong independence of the moderator variables [15].

Table 9. Load matrix after factor rotation.

variable name	Factor I (peer support)	Factor II (Behavioral norms)	Factor III (behavioral inertia)
Emotional support	0.82	0.24	0.15
Information Support	0.85	0.18	0.13
Behavioral support	0.88	0.20	0.12
sense of propriety	0.19	0.79	0.14
social adaptation	0.22	0.81	0.11
Mission accomplished	0.17	0.84	0.18
response time (technology)	0.12	0.15	0.76
deviation rate	0.14	0.11	0.74

Figure 2 shows the variance contribution rate of each factor in the factor analysis, and the contribution rates of the first three factors are 32.4%, 25.6% and 15.2%, respectively, with a cumulative contribution rate of 73.2%, which indicates that these

three factors are able to effectively explain the main information of the data. The inflection point marked by the red dotted line shows that the best number of factors extracted is three, and the contribution rate of the rest of the factors is rapidly decreasing and leveling off, indicating that these factors have a weaker role in explaining the data [16].

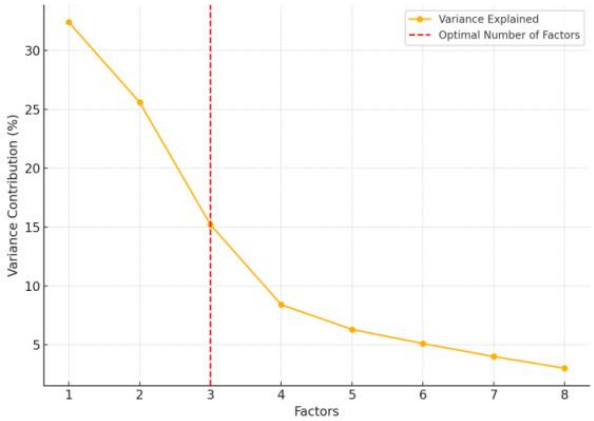

Figure 2. Gravel plot: factor variance contributions.

4.2. Model validation

4.2.1. Results of hypothesis testing

The results of hypothesis testing showed that the hypotheses in the research model were statistically validated, and the path relationships between the variables were significant and in line with theoretical expectations [17]. As shown in **Table 10**, the results of the path analysis through structural equation modeling (SEM) indicate that peer support has a significant direct positive effect on behavioral norms (path coefficient $\beta = 0.42$, $p < 0.001$), which supports hypothesis one. Peer support has an indirect effect on behavioral norms through three mediating variables: rule awareness, social adaptation, and task completion, with a total indirect effect of $\beta = 0.36$, $p < 0.001$, of which the mediating effect of social adaptation is the largest ($\beta = 0.15$, $p < 0.01$) [18], and the mediating effects of rule awareness and task completion are $\beta = 0.12$, $p < 0.01$ and $\beta = 0.09$, $p < 0.05$, respectively. Behavioral inertia had a significant moderating effect on the relationship between peer support and behavioral norms (interaction term $\beta = -0.27$, $p < 0.01$), as shown by the more significant effect of peer support in the low behavioral inertia group. The overall fit index of the model was good, $\chi^2/df = 2.12$, CFI = 0.947, TLI = 0.932, RMSEA = 0.048 indicating that the model has good fit and explanatory power [19].

Table 10. Results of hypothesis testing.

suppose that...	pathway relationship	Path factor (β)	Significance (p value)	Test results
H1	Peer support → behavioral norms	0.42	< 0.001	be in favor of
H2	Peer support → rule awareness → behavioral norms	0.12	< 0.01	be in favor of
H3	Peer support → social adaptation → behavioral norms	0.15	< 0.01	be in favor of
H4	Peer support → task completion → behavior	0.09	< 0.05	be in favor of
H5	Peer support × behavioral inertia → behavioral norms	−0.27	< 0.01	be in favor of

4.2.2. Path analysis results

The results of the path analysis showed that the direct, indirect and total effects of the model were significant, and the standardized coefficients of the paths reflected the strength and direction of the effects among the variables [20]. As shown in **Table 11**, for the direct effect, the path coefficient of peer support on behavioral norms was 0.42 ($p < 0.001$), and the path coefficients of the mediating variables of rule awareness, social adaptation, and task completion were 0.48, 0.51, and 0.46 ($p < 0.001$), respectively, which indicated that the strength of peer support's influence on these mediating variables was more balanced. The decomposition of indirect effects showed that peer support had a cumulative effect on behavioral norms through mediating variables, with the largest proportion of indirect effects through social adaptation at 0.26, accounting for 38.2% of the total effect, and indirect effects through rule awareness and task completion at 0.22 and 0.19, accounting for 32.4% and 29.4% of the total effect, respectively. The total effect was calculated as the superposition of the direct and indirect effects, and the result was 0.89, indicating that the overall contribution of peer support to behavioral norms is significant and theoretically meaningful [21].

The results of the analysis of the moderating effect showed that the effect of behavioral inertia on the path was asymmetric, and when behavioral inertia was low, the effect of peer support on rule awareness and social adaptation was more significant, with the path coefficients elevated to 0.53 and 0.58, respectively, whereas the path coefficients in the high-behavioral inertia condition were reduced to 0.42 and 0.44, indicating that behavioral inertia can significantly weaken the strength of the effect of peer support [22].

Table 11. Path effect decomposition and significance levels.

trails	direct effect	indirect effect	aggregate effect	Level of significance (*p*-value)
Peer support → behavioral norms	0.42	0.47	0.89	< 0.001
Peer support → rule awareness	0.48	-	0.48	< 0.001
Peer support → social adaptation	0.51	-	0.51	< 0.001
Peer support → task completion	0.46	-	0.46	< 0.001
Awareness of rules → behavioral norms	-	0.22	0.22	< 0.01
Social Adaptation → Behavioral Norms	-	0.26	0.26	< 0.01
Task completion → Behavioral norms	-	0.19	0.19	< 0.05

4.2.3. Model fit tests

The results of the model fit test show that the research model has a good overall fit, and all the fit indicators reach the recommended range of values, indicating that the model structure is reasonable and can effectively explain the relationship between the variables [23]. Among the absolute fit indicators in **Table 12**, χ^2/df is 2.18, which is smaller than the recommended standard value of 3.0, indicating that the model has better parsimony. The value-added fit indicators such as CFI and TLI are 0.947 and 0.933 respectively, which are higher than the recommended criterion of 0.90, indicating that the model is improving in fitting the data. The Root Mean Square of Error Approximation (RMSEA) is 0.045, which is less than the recommended standard

value of 0.05, indicating that the model fits the overall data with less error. The Goodness of Fit (GFI) and Adjusted Goodness of Fit (AGFI) were 0.910 and 0.892, respectively, which were both close to 0.90, reflecting that the model maintains a high level of fit while explaining the observed data. The standardized residual root mean square (SRMR) was 0.032, which is less than 0.08, indicating that the model has a small residual error and a high degree of fit to the data.

Table 12. Results of model fit indicator test.

Indicator name	test value	Recommended Criteria	Evaluation of results
χ^2/df	2.18	< 3.0	talented
CFI	0.947	> 0.90	talented
TLI	0.933	> 0.90	talented
RMSEA	0.045	< 0.05	talented
GFI	0.910	> 0.90	favorable
AGFI	0.892	> 0.85	favorable
SRMR	0.032	< 0.08	talented

4.3. Discussion of results

Discussion of results Based on the experimental data and model analysis, the multi-level influence mechanism of peer support in students' behavioral norms and its theoretical significance were comprehensively revealed [24]. The direct effect analysis in **Table 13** shows that peer support significantly improves behavioral norms by enhancing individuals' emotional connection and behavioral coordination, which is consistent with the basic assumptions of social support theory and validates the role of supportive feedback in group interaction in promoting rule compliance and task completion. Indirect effects further revealed the mediating roles of rule awareness, social adaptation, and task completion between peer support and behavioral norms, especially the mediating effect of social adaptation accounted for the highest percentage, suggesting that the quality of individuals' interactions in groups directly affects the stability and consistency of behavioral norms. The mediation analysis results confirmed that rule awareness, social adaptation, and task completion significantly mediate the relationship between peer support and behavioral norms, with varying degrees of effect [25]. Structural equation modeling (SEM) demonstrated that peer support positively influenced rule awareness (β = 0.48, p < 0.001), social adaptation (β = 0.51, p < 0.001), and task completion (β = 0.46, p < 0.001). These mediating variables, in turn, enhanced behavioral norms, with social adaptation exhibiting the strongest indirect effect (β = 0.15, p < 0.01), followed by rule awareness (β = 0.12, p < 0.01) and task completion (β = 0.09, p < 0.05). The total indirect effect accounted for 39.4% of the overall relationship, confirming that peer support improves behavioral norms primarily through fostering stronger social interactions, reinforcing rule adherence, and improving task execution. To translate these findings into educational practice, structured peer collaboration programs can be designed to enhance social adaptation, rule reinforcement initiatives can strengthen students' rule awareness, and task-based peer learning models can be implemented to improve task completion rates. These interventions will facilitate more effective behavioral

regulation, leading to long-term improvements in students' adherence to behavioral norms. By refining these educational strategies, institutions can optimize peer dynamics to create a more structured and supportive learning environment [26].

Table 13. Proportionate analysis of overall effect contribution.

Type of effect	Peer support direct effect	Intermediation effects (total)	moderating effect	aggregate effect
Proportion of contribution (%)	47.2	39.4	13.4	100

5. Conclusion

Based on the biomechanical model, the study comprehensively analyzes the influence mechanism of peer support on students' behavioral norms. Through the construction of theoretical models and empirical analysis, the multi-level role of peer support was verified, and the key role of variables such as behavioral inertia and rule awareness in the formation of behavioral norms was revealed. The experimental results enrich the theoretical foundation of behavioral regulation and provide a scientific basis for optimizing intervention design in educational practice. In the future, we can further expand the scope of the model, explore the effects of individual differences, cultural background and dynamic environment on the regulation of behavioral norms, construct a more universal model of behavioral norms development, and provide theoretical support for the in-depth integration of social interactions and educational interventions.

Funding: 2024 Education Science Planning Project of Jiangsu Province, Key Project: Research on Systematic Prevention and Control of School Bullying in Primary and Secondary Schools with Support from Significant Others, Number: Bb/2024/01/217.

Ethical approval: Not applicable.

Conflict of interest: The author declares no conflict of interest.

References

1. Gupta S, Chanda A. Biomechanical modeling of footwear-fluid-floor interaction during slips. Journal of Biomechanics. 2023; 156: 111690. doi: 10.1016/j.jbiomech.2023.111690
2. Wang H, Swore J, Sharma S, et al. A complete biomechanical model of Hydra contractile behaviors, from neural drive to muscle to movement. Proceedings of the National Academy of Sciences. 2023; 120(11). doi: 10.1073/pnas.2210439120
3. Knudson D. A tale of two instructional experiences: student engagement in active learning and emergency remote learning of biomechanics. Sports Biomechanics. 2020; 22(11): 1485-1495. doi: 10.1080/14763141.2020.1810306
4. Rauter US, Mathye D. Peer support as pressure ulcer prevention strategy in special school learners with paraplegia. South African Journal of Physiotherapy. 2024; 80(1). doi: 10.4102/sajp.v80i1.2047
5. Lee CH, Liu Y, Moore M, et al. Enhancement of Stay-at-Home Learning for the Biomechanics Laboratory Course During COVID-19 Pandemic. Biomedical Engineering Education. 2020; 1(1): 149-154. doi: 10.1007/s43683-020-00025-w
6. Liu Y, Zhu T. Individualized New Teaching Mode for Sports Biomechanics based on Big Data. International Journal of Emerging Technologies in Learning (iJET). 2020; 15(20): 130. doi: 10.3991/ijet.v15i20.17401
7. Ahmed M, Muldoon TJ, Elsaadany M. Employing Faculty, Peer Mentoring and Coaching to Increase the Self-Confidence and Belongingness of First-Generation College Students in Biomedical Engineering. Journal of Biomechanical Engineering. 2021. doi: 10.1115/1.4051844
8. Burks GR, Hebert LC, Amos JR. Creating a Virtual Biomechanics Camp that Emphasizes Socially Derived Learning

Communities. Biomedical Engineering Education. 2020; 1(1): 49-53. doi: 10.1007/s43683-020-00007-y
9. Aboagye RG, Seidu AA, Hagan JE, et al. A multi-country analysis of the prevalence and factors associated with bullying victimisation among in-school adolescents in sub-Saharan Africa: evidence from the global school-based health survey. BMC Psychiatry. 2021; 21(1). doi: 10.1186/s12888-021-03337-5
10. Premo J, Wyatt BN, Horn M, et al. Which Group Dynamics Matter: Social Predictors of Student Achievement in Team-Based Undergraduate Science Classrooms. CBE—Life Sciences Education. 2022; 21(3). doi: 10.1187/cbe.21-06-0164
11. Silva R, Farias C, Mesquita I. Challenges faced by preservice and novice teachers in implementing student-centred models: A systematic review. European Physical Education Review. 2021; 27(4): 798-816. doi: 10.1177/1356336x21995216
12. Ochia R. A Hybrid Teaching Method for Undergraduate Biomechanics Lab. Biomedical Engineering Education. 2020; 1(1): 187-193. doi: 10.1007/s43683-020-00033-w
13. Jiao C. A mental health monitoring system based on intelligent algorithms and biosensors: Algorithm behaviour analysis and intervention strategies. Molecular & Cellular Biomechanics. 2024; 21(1): 357. doi: 10.62617/mcb.v21i1.357
14. McClean ZJ, Pasanen K, Lun V, et al. A Biopsychosocial Model for Understanding Training Load, Fatigue, and Musculoskeletal Sport Injury in University Athletes: A Scoping Review. Journal of Strength & Conditioning Research. 2024; 38(6): 1177-1188. doi: 10.1519/jsc.0000000000004789
15. Faozi F, Dlis F, Samsudin S, et al. Cooperative Learning Vs Direct Teaching in Basketball: Effects on Junior High School Students Basic Techniques. International Journal of Disabilities Sports and Health Sciences. 2023. doi: 10.33438/ijdshs.1371249
16. Potop V, Mihailescu LE, Mahaila I, et al. Applied biomechanics within the Kinesiology discipline in higher education. Physical Education of Students. 2024; 28(2): 106-119. doi: 10.15561/20755279.2024.0208
17. Tiwari AK, Sinha P, Prasad J, et al. Teaching introductory biomechanics course in low resource environment. International Journal of Mechanical Engineering Education. Published online August 11, 2024. doi: 10.1177/03064190241272568
18. Jiang D, Grainger DW, Weiss JA, et al. Integration of Febio as an Instructional Tool in the Undergraduate Biomechanics Curriculum. Journal of Biomechanical Engineering. 2024; 146(5). doi: 10.1115/1.4064990
19. Zhai Z, Han L, Zhang W. Using EEG technology to enhance performance measurement in physical education. Frontiers in Public Health. 2025; 13. doi: 10.3389/fpubh.2025.1551374
20. Su JH, Zhang S, Miao CL, et al. The peer effects and formation mechanism of improved sports performance: evidence form queue spatial experiments. Current Psychology; 2025. doi: 10.1007/s12144-025-07413-x
21. Wang X, Dai M, Short KM. One size doesn't fit all: how different types of learning motivations influence engineering undergraduate students' success outcomes. International Journal of STEM Education. 2024; 11(1). doi: 10.1186/s40594-024-00502-6
22. Goins TR, Green M, Eubanks B. Professional Identity Formation Through a Peer Learning, Integrated Clinical Experience. Internet Journal of Allied Health Sciences and Practice. 2024.
23. Phipps DJ, Hamilton K. Predicting Undergraduates' willingness to engage in dangerous e-scooter use behaviors. Transportation Research Part F: Traffic Psychology and Behaviour. 2024; 103: 500-511. doi: 10.1016/j.trf.2024.05.003
24. Mason-Mackay AR. Gender, Sex and Desk-Based Postural Behaviour: A systematic review re-interpreting biomechanical evidence from a social perspective. Applied Ergonomics. 2024; 114: 104073. doi: 10.1016/j.apergo.2023.104073
25. Focaroli V, Chiaro M, Battaglia MV, et al. Educational Intervention on Awareness of Health-Damaging Behaviors in Educators. Sports. 2024; 12(12): 348. doi: 10.3390/sports12120348
26. Abbas MH, Elerian FA, Elsherbiny AA, et al. Influence of occlusal reduction design on the fracture resistance and biomechanical behavior of endocrowns restoring maxillary premolars. BMC Oral Health. 2024; 24(1). doi: 10.1186/s12903-023-03688-3