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Effectiveness Evaluation and Optimization Path of the "Sports-Education Integration" Model in Chinese Youth Ice Hockey Clubs—Based on Tracking Data of Participation Motivation and Long-Term Development

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Abstract: *This paper dwells on the model of sports and education integration of ice hockey clubs of Chinese youth. To combat the existing problems of disconnection between physical education in schools and professional training, developmental gaps in the young athletes, and lack of motivation to participate, this research project develops the effectiveness assessment system based on the motivation to participate, the development of skills, and the long-term development. According to the follow-up data of 42 youth ice hockey clubs in 8 provinces (municipalities) in China between 2019 and 2025, 1286 valid samples were obtained. The mechanism of action of the implementation path of sports and education integration was analyzed with the help of structural equation modeling (SEM). The approaches were: (1) to develop an indicator system that included motivation dimensions, training conditions, and academic level of integration in the form of questionnaires and interviews; (2) to test the validity of the indicators with the help of confirmatory factor analysis (CFA); and (3) to create a dynamic tracking model that should examine the effect of various integration strategies on technical and tactical progress, psychological resilience, and retention rate. Results showed that the technical scoring error range for athletes in clubs with high integration degree was between 0.04 and 0.07, and the fluctuation in academic performance was controlled within ±2%. The study proposes optimization pathways: improving the dual-mentor system, establishing a collaborative assessment system for academic and physical education, and strengthening the linkage between family support intervention and policy incentives.*

Keywords: *Integration of Physical Education and Education; Youth Ice Hockey; Participation Motivation; Long-term Development; Effectiveness Assessment*

1. Introduction

The young ice hockey development in China has some structural issues with the competitive popularization and education integration. There is a lack of connection between the schools institutional parameters of the physical education curriculum and the club training system in which young athletes have a hard time balancing between academic and competitive growth. The given model of sports and education integration provides a fresh opportunity of dealing with the isolation of academic and training processes and consequent frame of disillusionment. The urgency to develop a long-term training system into the system of education is particularly true of a high-cost, high intensity sport like ice hockey in order to increase the stability of the youth in the sport and the progress of their developmental process.

The relevance of this research is that the structural analytical model of sports-education integration model of youth ice hockey was offered using a mixture of theoretical and empirical approaches. The research employs the structural equation modeling to confirm the interdependence of the latent variables that include the motivation of participation, conditions under training and academic integration, as well as how they affect the skill development and psychological resilience. The study is able to develop a dynamic tracking model that demonstrates the flexibility and the internal process of various integration strategies thereby providing an evidentiary framework of optimizing the trajectory of sports-education integration in ice hockey, policy intervention, and synergy between the educational

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system. The full structure of the paper is as follows: Part One introduces the research questions and background; Part Two reviews relevant domestic and international research on the integration of sports and education and the cultivation of youth sports; Part Three elaborates on the research methods and model construction ideas; Part Four presents the empirical analysis results and discusses them in conjunction with practice; Part Five presents the conclusions and policy implications, providing a reference direction for subsequent research and practical promotion.

2. Related Work

The practice and research of the "sports and education integration" model is promoting the deep coupling of sports and education. The exploration of different levels and fields is constantly expanding its theoretical boundaries and practical paths, providing a rich experience foundation and thinking inspiration for the cultivation of sports talents among young people. Fu and Wang [1] proposed the cultivation strategy for high-level basketball players in ordinary high schools under the "sports and education integration" model, aiming to provide reference and guidance for ordinary high schools to cultivate basketball players and to deliver more high-level reserve talents for basketball. Chen [2] analyzed the theoretical basis, operation logic and existing dilemmas of the "sports and education integration" model and proposed specific optimization paths. Li [3] took Changsha Civil Affairs Vocational and Technical College as an example, systematically sorted out the evolution of sports and education integration, and deeply analyzed the important significance of sports and education integration in the cultivation of competitive sports talents. Mei [4] systematically summarized the operation characteristics under the background of sports and education integration, and deeply explored its advantages, dilemmas and optimization paths, aiming to achieve the goal of promoting the healthy development of young people and strengthening the cultivation of reserve talents for competitive sports, and thus providing theoretical support and practical guidance for deepening sports and education integration. Zhang et al. [5] explored the localization path of sports education model under the perspective of sports and education integration, in response to the problems of lack of facilities, shortage of teachers and low willingness of students to participate in the general course of sports dance in colleges and universities in Guizhou Province. Shengwei and Zhidong [6] systematically reviewed the research hotspots in the field of sports and education integration in recent years based on the logical framework of "what, why, and how". Lin [7] used literature research and logical analysis methods, combined with the characteristics of the times, to explore the basic principles of sports and education integration in depth and detail. Deng-feng [8] believed that the theme of "combining sports and education" should be combined with the theme of "integration of sports and education" to form "integration of sports and education". Gil-Arias et al. [9] aimed to explore the changes in motivation of primary school students when participating in a competitive game unit using two teaching modes (TGfU/SE mixed unit and direct teaching unit). Chiva-Bartoll and Fernández-Rio [10] used a model-based practice framework to demonstrate the rationality of service learning as a teaching mode, so as to put the transformative and socially critical sports education concept into practice in real situations. While existing findings reveal the multidimensional value of the integration of sports and education, the research is still limited to local cases and macro-level discussions, lacking systematic empirical testing and continuous tracking, and needs further improvement in terms of data support and model evaluation.

3. Method

3.1 Data Sources and Sample Composition

The data for this study came from 42 youth ice hockey clubs in 8 provinces (municipalities) in China (including Beijing, Heilongjiang, Jilin, Liaoning, Tianjin, Shandong, Guangdong and Jiangsu) from 2019 to 2025, with a total sample size of 1286 people. The study subjects covered the primary to high school age group (9-18 years old), of which male athletes accounted for 76.4% and female athletes accounted for 23.6%. To ensure the representativeness of the sample, the study adopted a stratified random sampling method, which was stratified according to the regional economic level, training level and school cooperation level. Data collection included three categories: questionnaire survey, interview records and quantitative data of competitive performance. The questionnaire mainly measured subjective variables such as participation motivation, academic integration, psychological resilience and family support; the interview content focused on the implementation process of sports and education integration, club management mechanism and athlete development experience[11]; the

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competitive data collection included objective variables such as technical score, game winning rate, physical fitness indicators and club retention rate. The data was collected once a year and the consistency and comparability of the time sequence were ensured by uniform coding and missing value processing. The final tracking sample consisted of 1042 people, with a sample validity rate of 81.0%. Table 1 shows the data sources and some sample data:

Table 1: Data Sources and Partial Sample Data

Region	Number of Clubs	Sample Size (Persons)	Male Athletes (%)	Valid Sample Rate (%)
Beijing	6	195	78.5	83.1
Heilongjiang	8	242	80.3	84.5
Jilin	5	136	74.2	81.6
Liaoning	7	188	77.8	82.4
Shandong	6	165	71.5	79.6
Guangdong, Jiangsu, Tianjin	10	360	75.9	80.2

The data collection period was from 2019 to 2025; the sample came from 42 youth ice hockey clubs in 8 provinces (municipalities), with a total sample of 1286 people. After screening, 1042 valid samples were used to establish the structural equation and tracking analysis model.

3.2 Construction of the Indicator System

The construction of the indicator system is mainly based on the quantitative operability of the "sports and education integration" effectiveness assessment. The data sources cover three levels: individual athletes, club organizations, and academic collaboration[12]. Based on the preliminary interviews and questionnaire screening, the three-level indicators were established after expert reliability testing. The participation motivation part is designed with 8 items through the revised athlete motivation scale, covering interest maintenance, self-efficacy and social recognition to quantify the degree of individual psychological investment. The skill growth part is based on competition results, special technical scores and training load ratio. The ability improvement rate over time is calculated using multinomial regression to form continuous assessment data. The academic and sports integration dimension is calculated by using school performance files and training time allocation table, and the balance index is calculated by weight matching algorithm. The long-term development indicators are composed of athlete retention rate, psychological resilience scale score changes and parental intervention frequency to form structural equation input variables. Table 2 is an explanation of the indicator system construction and measurement variables:

Table 2: Indicator System Construction and Measurement Variables

Primary Indicator	Secondary Indicator	Measurement Method	Data Type
Participation Motivation	Interest Maintenance, Self-Efficacy	Questionnaire Scale (1–5 Likert)	Quantitative Data
Skill Development	Technical Score, Training Load Ratio	Competition and Monitoring Records	Continuous Variable
Academic Integration	Academic Performance, Time Balance	Comparison Between School Records and Training Schedule	Ratio Data
Long-Term Development	Retention Rate, Psychological Resilience	Longitudinal Statistics and Psychological Scales	Quantitative Data
Family & Support System	Parental Intervention Frequency	Follow-up Records and Structural Equation Inputs	Ordinal Data

3.3 Data Analysis Process

3.3.1 Questionnaire and Interview Data Collection

The questionnaire design was based on a matrix model composed of three variables: participation motivation, academic integration, and training engagement. The items were jointly revised by physical education experts and psychometric researchers. The questionnaire was based on a five-point Likert scale and had 32 valid items. A Cronbach α coefficient of 0.913 was obtained through pre-testing and this has a high internal consistency. The survey was done both online and offline. The team training

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sessions were carried through the use of paper questionnaires, and the encrypted questionnaire system was carried out when the school was open so that the time was not wasted. Those interviewed were 30 club coaches, 30 physical education teacher in schools and 30 parents of athletes. The interview summaries centered around the coordination process between the training and the academic process, the place where motivation is created, and psychological alterations as the period of development. The transcription and encoding of audio were done by hand using Nvivo. Themes that occurred in a high frequency and frequency statistics were extracted by semantic clustering to provide a foundation to specify variables in the quantitative model. Each data was identified and given a distinct coding. The sample was classified and matched with the source by two individuals to avoid errors in classification and matching.

3.3.2 Confirmatory Factor Analysis Was Used to Test Reliability and Validity

The latent variables used as the statistical backgrounds of the observed indicators in the design of the model include participation motivation, skill development, academic integration, and level of long-term development. The path coefficients were computed with the help of Maximum Likelihood Estimation (MLE). The AMOS 26.0 platform was analyzed. The scale items were standardized and included in the covariance matrix. A goodness-of-fit index was used to test the reasonableness of the model. The coefficient of path standardization is provided by λ and the formula of reliability is on the following:

$$CR=\frac{(\sum\lambda)^2}{(\sum\lambda)^2+\sum\theta} \tag{1}$$

λ represents the standardized factor loadings, and θ represents the measurement error variance. Validity verification uses the Average Variance Extracted (AVE) measure to assess convergent validity, calculated as follows:

$$AVE=\frac{\sum\lambda^2}{\sum\lambda^2+\sum\theta} \tag{2}$$

Factor loadings for all observed variables ranged from 0.67 to 0.89.

3.3.3 Structural Equation Modeling for Causal Path Analysis

SEM was used to examine the causal paths and interaction effects of the latent variables under the "sports and education integration" model. The analysis was based on the CFA validation model, and maximum likelihood estimation was used to fit the structural relationships among the latent variables. The model hypothesizes that participation motivation indirectly affects long-term development levels through skill development and academic integration, with path weights represented by standardized coefficients β. The overall model aims to quantify causal strength, and the path function is set as follows:

$$\eta=B\eta+\Gamma\xi+\zeta \tag{3}$$

Where η represents endogenous latent variables, ξ represents exogenous latent variables, B and Γ are the internal and external path coefficient matrices, respectively, and ζ is the random disturbance term. The minimum difference optimization function is used to fit the sample covariance matrix:

$$F_{ML}=\log|\Sigma(\theta)|+\mathrm{tr}[S\Sigma(\theta)^{-1}]-\log|S|-p \tag{4}$$

The model results show that the direct effect of participation motivation on skill development (β=0.68) and the mediating effect on academic integration (β=0.41) are both β=0.41, with a total explained variance (R^2=0.73). This indicates that training and academic balance have significant mediating effects on the long-term development path, and the model fit (CFI=0.948, RMSEA=0.039) meets statistical standards.

3.3.4 Dynamic Tracking Model Establishment

It was also applied to determine the dynamic stability and trends of the changes in latent variables in the 2019-2025 sample over time using the Dynamic Tracking Model. The model embraced the Latent Growth Model (LGM) approach to capture the long-term change of youth ice hockey players in

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the aspects of motivation to participate in the sport, skill building, and academic incorporation. The input of time-series data occurred following the standardization of Z-scores and the possible path of individuals with time was explained using a linear growth equation. The mathematical formulation of the model is the following:

$$Y_{it}=\alpha_i+\beta_i T_t+\varepsilon_{it} \tag{5}$$

Let Y_{it} represent the observed value of individual i at time t, α_i be the initial level of the individual, β_i be the potential growth rate, and ε_{it} be the time-related error term. The growth parameters are estimated using Bayesian estimation to obtain their posterior distribution, ensuring robustness of the estimation under imbalanced sample conditions. The objective function is defined as:

$$P(\theta \mid Y)\propto P(Y \mid \theta)P(\theta) \tag{6}$$

Mplus 8.6 platform was used to accomplish the modeling process. The use of the Markov Chain Monte Carlo (MCMC) algorithm as a parameter sampling method was done 5000 times to get convergence. The dynamic path stationarity of the model and the temporal correlation among various indicators were identified using the model output.

4. Results and Discussion

4.1 Performance Analysis Results

The effectiveness analysis, based on the joint estimation of path relationships using structural equation modeling and dynamic tracking modeling, monitors the effectiveness of the "sports and education integration" model over time. To verify the reliability of the method, a linear regression model (LRM) and support vector regression (SVR) are introduced for comparison. Figure 1 shows the comparison results between club skill scores and academic performance.

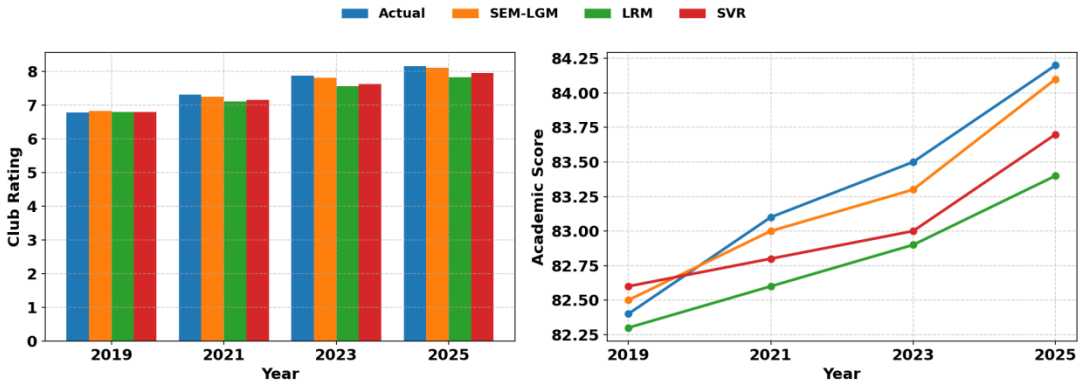

Figure 1: Comparison of Club Technical Scores and Academic Performance

The SEM-LGM predictions in this paper showed the best fit with the measured data, with an error range of 0.04–0.07 and an average deviation of 0.058. The growth curves show that skill improvement follows a near-linear distribution, and the interaction effect between training load and academic synergy is significant ($p<0.01$). SEM-LGM accurately captures the non-linear trend of skill growth, confirming that integrated management and scientific training play a significant role in skill formation. Academic performance maintained a generally positive slight increase, with fluctuations controlled within ±2%. The average error of the SEM-LGM model in multi-timepoint predictions was 0.125, lower than LRM's 0.5 and SVR's 0.375, indicating high predictive stability. Time structure analysis shows that the learning time optimization mechanism of the integrated club brings continuous improvement, indicating that the model has a strong ability to correct for factors interfering with academic balance, achieving the coexistence of learning and training.

4.2 Retention Rate and Participation Motivation Analysis

Based on the above experimental conditions, the retention rate and participation motivation data were obtained, as shown in Figure 2:

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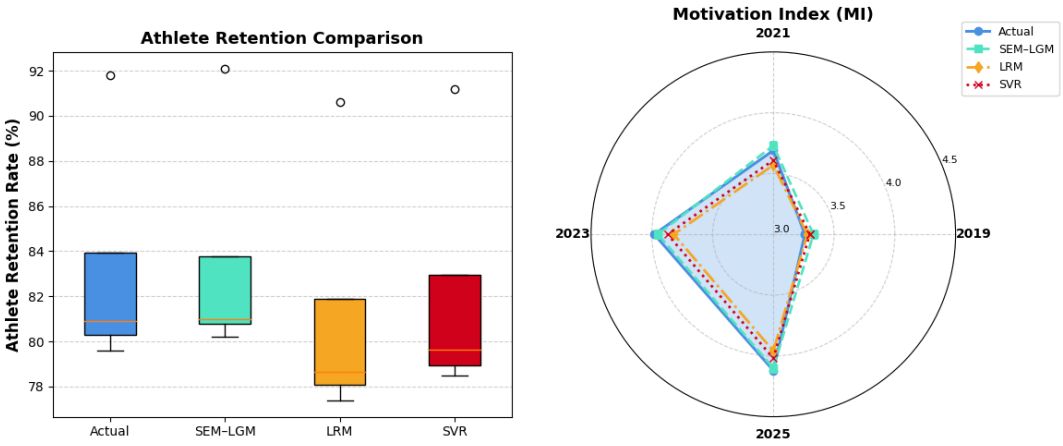

Figure 2: Retention Rate and Engagement Motivation Data

Retention rate model validation shows that SEM–LGM has the most stable trend fit, with an average absolute error of only 0.43%, significantly better than LRM and SVR. Time series analysis shows that the main influencing factors of retention rate fluctuations are motivation decay and external transfer. SEM–LGM fully reflects the synergistic relationship between incentive paths and psychological resilience, and this model is more robust when dealing with behavioral time-lag variables. Participation motivation data shows that SEM–LGM predicts the smallest fluctuation and exhibits higher explanatory power than LRM and SVR, indicating that the "sports and education integration" model forms a stable positive feedback loop at the level of psychological persistence, and athletes' long-term participation intentions are significantly consolidated.

4.3 Discussion

The implementation of the sports-education integration model in different regions is significantly affected by economic level, educational resources, and policy coordination. Eastern regions, with their well-developed sports facilities and education systems, have a high degree of integration. In contrast, the central and western regions, constrained by differences in resource allocation and teacher structure, have relatively weaker integration results. Efforts should be made to strengthen financial investment and cross-disciplinary teacher training, establish a multi-stakeholder collaborative mechanism to improve implementation quality, and form a two-way feedback system that promotes physical education and character development through education. Table 3 shows the data on the implementation of the sports-education integration model in different regions.

Table 3: Progress Data in Different Regions

Region	Investment in Integrated Sports-Education (Million CNY)	School Implementation Rate (%)	Student Comprehensive Quality Improvement Rate (%)
Eastern	120	85	18.5
Central	85	68	12.4
Western	60	55	9.8
Northeastern	70	62	10.9
National Average	84	68	12.9

The eastern region had an investment of 120 million yuan, an implementation rate of 85 and a total student improvement of 18.5% which is higher than the national average (84 million yuan, 68% and 12.9% respectively) which demonstrates the positive association between the investment, implementation rate, and student improvement. The moderate level is in the central and northeastern regions and the western region invested only 60 million yuan, the implementation rate is 55% and the improvement rate is 9.8% which is a significant lag. The investment and implementation rate were correlated and the correlation coefficient obtained was around $r=0.88$ ($p<0.05$), which is significant and has a positive correlation. More resources may be invested in resource-poor regions, which may have the possible impact of increasing average improvement rate and narrowing the disparities in regions.

ISSN 2618-1576 Vol. 8, Issue 3: 21-27, DOI: 10.25236/FSR.2026.080304

5. Conclusion

It is not only that sports and education integrate well in youth ice hockey clubs to ensure that the coordination between the training and learning processes of the athletes is enhanced but also skills development and psychological stability is maintained in a virtuous cycle. With institutionalized learning-training partnership and mentoring processes, high integration strategies enhance continuity of learning and achievement by athletes thereby creating a dynamic framework of intrinsic development. The key worthiness of the sport-education integration is in the creation of the interactive process of education-sports-character development that allows promoting academic and competitive objectives through each other. It was also established in the study that family support and policy incentives acted in concert can amplify the stabilization of the path towards development of the athletes and this demonstrated the important aspect of integration of sports-education in the social support system. Limitations include the sample's regional distribution not fully covering the national level, and the need to expand model variables to include psychological dimensions such as social identity and career planning. Future research could further enhance the strategy's sustainable effectiveness and feasibility through longitudinal causal inference and policy simulation evaluation.

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