Cultivation and Regression Analysis of Children's Mental Toughness under the Intervention of Sports Perseverance Mechanism

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Abstract

With the rise of exercise psychology, society emphasizes the physical and psychological health of children and adolescents. If sports intervention is performed regularly, children and adolescents will develop a more resilient mindset, greater self-assurance, and a greater tolerance for setbacks. However, the relevant research lacks quantitative analysis and fails to investigate the mediation effect of the mechanism underlying sports perseverance. Consequently, this research investigates the cultivation and regression analysis of children's mental toughness under the sports perseverance mechanism. First, a model was developed to examine the sports perseverance intervention aimed at improving the mental toughness of youngsters. Next, a multi-factor cointegration test was conducted on the time series of the measured values of children's mental toughness in response to sports perseverance. In addition, the error correction model and the breakpoint regression model were developed to identify the instances in which the time series diverge from the equilibrium state and return to normal. Experiments were conducted to get the test results of the presented models, which demonstrate their efficacy.

Keywords: sports perseverance mechanism; children's mental toughness; regression analysis

1. Introduction

Children and youth are the future builders and inheritors of the country. Their physical and mental well-being has increased societal interest (Fergeus et al., 2017; Hankala et al., 2017; Liu, 2021; Turner et al., 2021). With the development of exercise psychology, repeated domestic and international studies have confirmed that physical activity may sustain mental health and progressively alter our mental state (Kushwaha & Hajare, 2021; Li & Liu, 2012; Liu, 2014; Palit & Chatterjee, 2006; Wang, Song, & Qin, 2017; Zhang, 2020; Zhang et al., 2021). Mental resilience under adversity is characterized by mental elasticity, strength, and regenerative capacity (Cai & Jin, 2021; Gao, Qiao, & Mei, 2019; Puswiartika & Gatot, 2020; Shojaei-Miandoragh, Bijani, & Abbasi, 2020). Despite the pressure of competitive sports, mentally tough athletes can maintain high confidence, focus, and motivation levels. If sports intervention is performed regularly, children and adolescents will develop a more resilient mindset, greater self-assurance, and a greater tolerance for setbacks.

Psychological measures are widely studied domestically and internationally. Xu, Wu, and Zhu (2021) investigated the association between students' mental flexibility, emotional equilibrium, and mental health during the COVID-19 outbreak. In particular, 512 students were polled using a self-designed questionnaire, the Connor-Davidson Resilience Scale 10 (CD-RISC10), the agitated behavior scale (ABS), and the Kessler Psychological Distress Scale (K10). The results indicate that as the pandemic lasted longer, the proportion of pupils with negative emotions increased, and mental flexibility decreased between the intermediate and upper levels. Emotional balance and mental health belonged to the middle level. After reviewing a large body of literature, it was discovered that certain local and international experts had conducted extensive research on mental toughness. To boost the early mental health of children, Gabrielli et al. (2018) devised an intervention strategy based on mental resiliency, which included a family-oriented intelligent counseling program. The intervention measure would be validated by five large-scale pilot programs involving 6,000 families in Spain, Italy, Iceland, Denmark, and Poland. Yue and Fangli (2018) observed and discussed the correlations between college students' mental health, mental elasticity, and stressful events.

Additionally, they administered a questionnaire survey to 320 college students using the college students' mental elasticity scale, adolescents' stressful event scale, and Symptom Checklist 90. The survey results reveal significant relationships between mental health, mental elasticity, and stressful experiences among college students. Zahran et al. (2011) investigated the association between natural disasters and mental health recovery, established a measurable notion of anti-disaster capability in mental health, and calculated the economic cost of the mentally unwell days caused by natural disasters. The results of experiments indicate that the ability to recover in mental health is a two-dimensional term involving both resistance and recovery time.

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Before conducting their research, the writers combed through numerous literature databases, compiled a status report of domestic and internationally relevant research, and consulted pertinent books. It was revealed that current research has qualitatively explored the relationship between students' physical activity and their mental toughness and well-being and has provided helpful recommendations for enhancing students' mental toughness. But relatively few researchers discussed sports intervention, let alone conducted empirical research on this topic. In light of this, this research aims to investigate the cultivation and regression analysis of children's mental toughness via the sports perseverance mechanism. The second section examines the action mechanism of sports perseverance intervention on children's mental toughness. It establishes a model for analyzing the sports perseverance intervention about children's mental toughness. The third section conducts a multi-factor cointegration test on the time series of the quantified values of children's mental toughness under the intervention of sports perseverance, constructs the error correction model and breakpoint regression model, and identifies the moments that the time series deviate from the equilibrium state and return to normal. Experiments validated the viability of the proposed models.

2. Modeling of the Intervention of Sports Perseverance Mechanism

Long-term, consistent physical activity significantly positively influences both physiological and mental health. It reduces negative responses (such as anxiety and despair) and increases happy responses (e.g., self-efficacy, health, and energy). The mental health and mental toughness of the youngsters who insist on engaging in physical activity are directly proportional to the intensity of their physical activity. Physical exercise can lead and cultivate youngsters to improve their mental fortitude and enable them to avoid mental issues (such as anxiety and depression) under an intense academic load. Participation and persistence are the keys to physical fitness. Through physical activity, children's minds and spirits will be revitalized, initiating a cycle of mental equilibrium, mental activation, cognitive adjustment, and behavioral modification.

This section mainly analyzes the action mechanism of sports perseverance intervention on children's mental toughness and builds up the following analysis model for sports perseverance intervention facing children's mental toughness. Let C_τ be the variation of the mean function; M_τ is the autoregressive integrated moving average (ARIMA) model; $\{M_\tau\}$ be the original time series of the quantified values of children's mental toughness without sports perseverance intervention. Then, the general intervention model $\{B_\tau\}$ can be expressed as:

$$B_\tau = C_\tau + M_\tau \quad (1)$$

Suppose the time series is affected by sports perseverance intervention at the moment Φ. Then, the time series $\{B_\tau, \tau<\Phi\}$ can be defined as the preintervention data of sports perseverance and used to recognize the model for the basic series $\{M_\tau\}$ without any intervention.

The step and pulse function can characterize the influence of sports perseverance intervention over the mean function of the quantified values of children's mental toughness. If sports perseverance intervention causes a permanent deviation of that function, then sports perseverance intervention must have a long-lasting impact on children's mental toughness. The following step dummy variable can describe the variable of sports perseverance intervention:

$$E_\tau^{(\Phi)} = \begin{cases} 1, \tau \geq \Phi \\ 0, Otherwise \end{cases} \quad (2)$$

Suppose sports perseverance intervention only occurs at the moment Φ, vanishes after one or several cycles, and exerts a short-term effect on the mean function. In that case, the impact of sports perseverance intervention lasts shortly in one or several cycles. The following pulse dummy variable can describe the variable of sports perseverance intervention:

$$Q_\tau^{(\Phi)} = \begin{cases} 1, \tau \geq \Phi \\ 0, Otherwise \end{cases} \quad (3)$$

According to the number of influencing cycles of sports perseverance intervention, and its influence on the mean function of the quantified values of children's mental toughness, sports perseverance intervention can be divided into four types:

(A) If there are many influencing cycles, the influence of sports perseverance intervention over the mean function can be considered permanent. Let φ be the permanent change to the mean of the quantified values of children's mental toughness induced by sports perseverance intervention. Then, this type of sports perseverance intervention can be modeled as follows:

$$C_\tau = \phi E_\tau^{(\Phi)} \quad (4)$$

Since φ is unknown, the changing intensity of the time series' mean is unknown. If the influence of sports perseverance intervention is delayed by r cycles, then this type of sports perseverance intervention can be modeled as follows:

$$C_\tau = \phi E_{\tau-r}^{(\Phi)}, \quad (5)$$

(B) In real life, sports perseverance intervention does not necessarily take effect immediately. In most cases, sports perseverance intervention has a gradual and lasting impact on children's mental toughness. Then, this type of sports

perseverance intervention can be modeled as follows:

$$C_\tau = \frac{\phi W}{1-\beta W} E_\tau^{(\Phi)}, 0 < \beta < 1 \quad (6)$$

(3) Sports perseverance intervention occurs suddenly and vanishes after one or several cycles. In this case, it only affects the mean function in a short time. Then, this type of sports perseverance intervention can be modeled as follows:

$$C_\tau = \phi Q_\tau^{(\Phi)} \quad (7)$$

(4) Sports perseverance intervention occurs suddenly, gradually weakens, and vanishes after one or several cycles. In this case, it only has a short-term impact on the mean function. Then, this type of sports perseverance intervention can be modeled as follows:

$$C_\tau = \frac{\phi W}{1-\beta W} Q_\tau^{(\Phi)}, 0 < \beta < 1 \quad (8)$$

The above types of sports perseverance intervention can be combined into a complex model for the influence of sports perseverance intervention on children's mental toughness:

$$C_\tau = \frac{\phi_1 W}{1-\beta W} Q_\tau^{(\Phi)} + \frac{\phi_2 W}{1-W} Q_\tau^{(\Phi)} \quad (9)$$

Or:

$$C_\tau = \phi_0 Q_\tau^{(\Phi)} + \frac{\phi_1 W}{1-\beta W} Q_\tau^{(\Phi)} + \frac{\phi_2 W}{1-W} Q_\tau^{(\Phi)} \quad (10)$$

Before applying the model of sports perseverance intervention, the attributes of sports perseverance intervention must be analyzed in light of the actual situation. The model parameters can be determined through maximum likelihood estimation.

3. Cointegration Test and Regression Analysis

3.1 Cointegration test

The Johansen tests for cointegration can verify the cointegration link between several elements of the time series of the quantitative values of children's mental toughness under sports persistence intervention. The various determinants include the number of cycles for the sports persistence intervention, the style of physical activity, the presence or absence of a teacher, etc. This work provides mathematical models for error correction and breakpoint regression to identify the instances when the time series of the quantitative values of children's mental toughness under sports perseverance intervention depart from the equilibrium state and return to normal.

Suppose there is a cointegration relationship within the time series of u quantifiable values of children's mental toughness. In that case, the long-term relationship between the time series variables that can characterize the degree of influence of sports perseverance intervention can be described as:

$$\delta_1 a_{1s} + \delta_2 a_{2s} + \ldots + \delta_u a_{us} = 0 \quad (11)$$

Formula (11) can be converted into a matrix:

$$A_s^{'} \delta = 0 \quad (12)$$

where, A_s and δ can be calculated by:

$$A_s = \begin{bmatrix} a_{1s} \\ a_{2s} \\ \cdots \\ a_{us} \end{bmatrix}, \delta = \begin{bmatrix} \delta_1 \\ \delta_2 \\ \cdots \\ \delta_u \end{bmatrix} \quad (13)$$

Through cointegration regression, the time series of the residual for the quantifiable values of children's mental toughness under sports persistence intervention can be determined. The residual series were then subjected to two Johansen cointegration tests: the trace test and the maximum characteristic root test.

The trace test confirms every identifying root. The condition assumed for the cointegration connection can be expressed as follows:

$$\begin{cases} G^{'}: There\ are\ at\ most\ q\ cointegration\ relationships; \\ G^{''}: There\ are\ n\ cointegration\ relationships. \end{cases} \quad (14)$$

Suppose there are SA-observed samples of children's mental toughness. Ranking all characteristic roots in descending order, the i-th characteristic root is denoted as μ_i. Then, the statistic can be expressed as:

$$TJ_{trace}(q|n) = -SA \sum_{i=q+1}^{n} \log(1-\mu_i) \quad (15)$$

In the maximum characteristic root test, the assumed condition for adjusting the cointegration relationship can be described by:

$$\begin{cases} G_q^{'}: There\ are\ at\ q\ cointegration\ relationships; \\ G_q^{''}: There\ are\ at\ least\ q+1\ cointegration\ relationships. \end{cases} \quad (16)$$

The statistic expression can be updated by:

$$\mathrm{TJ}_{\max}(q|q+1) = -SA\ log\left(1-\mu_{q+1}\right) = TJ_{trace}(q|n) - TJ(q+1|n) \quad (17)$$

where, q=0, 1, ..., n-1. The test starts from G'_0. If the null hypothesis is not rejected, then there is no cointegration relationship within the time series. If the null hypothesis is rejected, the test will be implemented on G'_1. If the null hypothesis is not rejected, then there is no cointegration relationship within the time series. If the null hypothesis is rejected, the test will be implemented on G'_2. The cointegration test on G'_3,...,G'_q is performed by analogy until the null hypothesis is not rejected.

On the time series of the quantified values of children's mental toughness under sports perseverance intervention, the Johansen tests for cointegration could bring five different results.

Let $CO_{\tau-1}$ be the cointegration vector. If variable B_τ contains no deterministic trend term and vector $CO_{\tau-1}$ contains no intercept term or trend term, then:

$$\begin{cases} \Psi^*(K)\Delta B_\tau = FP'CO_{\tau-1} + V_\tau = F \cdot CO_{\tau-1} + V_\tau \\ CO_{\tau-1} = P'B_{\tau-1} \end{cases} \quad (18)$$

The above situation is rarely the case in reality. If variable B_τ contains no deterministic trend term and vector $CO_{\tau-1}$ contains only the intercept term, then:

$$\begin{cases} \Psi^*(K)\Delta B_\tau = F \cdot CO_{\tau-1} + V_\tau \\ CO_{\tau-1} = P'B_{\tau-1} + d_0 \end{cases} \quad (19)$$

Any time series depicted by the above formula contains no

trend term. If variable B_τ includes a linear trend term and vector $CO_{\tau-1}$ has only the intercept term, then:

$$\begin{cases}\Psi^*(K)\Delta B_\tau = N_\tau + F \cdot CO_{\tau-1} + V_\tau \\ CO_{\tau-1} = P'B_{\tau-1} + d_0\end{cases} \quad (20)$$

Any time series depicted by the above formula contains a stochastic trend term. If variable B_τ includes a linear trend term and vector $CO_{\tau-1}$ has both the intercept term and the trend term, then:

$$\begin{cases}\Psi^*(K)\Delta B_\tau = N_\tau + F \cdot CO_{\tau-1} + V_\tau \\ CO_{\tau-1} = P'B_{\tau-1} + d_0 + d_1\tau\end{cases} \quad (21)$$

Any time series depicted by the above formula has a stable trend, i.e., contains both stochastic trend series and deterministic trend series. If variable B_τ contains a quadratic trend term and vector $CO_{\tau-1}$ contains both the intercept term and the trend term, then:

$$\begin{cases}\Psi^*(K)\Delta B_\tau = N_\tau[1,\tau]' + F \cdot CO_{\tau-1} + V_\tau \\ CO_{\tau-1} = P'B_{\tau-1} + d_0 + d_1\tau\end{cases} \quad (22)$$

The above situation is rarely the case in reality.

3.2 Regression analysis

Under actual sports tenacity interventions, the mental toughness of youngsters is not always consistent or balanced. When it is disrupted by schoolwork or family concerns, the cointegration relationship of the time series will differ from its typical value in the short term. This work develops an error correction model to examine deviations from the cointegration relationship.

Let b be the explained variable; a be the explanatory variable. Suppose the error correction model based on the residual series obtained in the preceding subsection contains only one b_τ and one a_τ. Let $E_{\tau-1}$ be the error correction term in the model. Then, the error correction model can be expressed as:

$$\Delta b_\tau = \gamma_0 + \gamma_1\Delta a_\tau + \mu E_{\tau-1} + \eta_\tau \quad (23)$$

The derivation process can be explained as follows:

$$b_\tau = \xi_0 + \xi_1 a_\tau + \xi_2 b_{\tau-1} + \xi_3 a_{\tau-1} + \eta_\tau \quad (24)$$

Subtracting $b_{\tau-1}$ from both sides of the above equation,

$$b_\tau - b_{\tau-1} = \xi_0 + \xi_1 a_\tau + (\xi_2 - 1)b_{\tau-1} + \xi_3 a_{\tau-1} + \eta_\tau \quad (25)$$

Subtracting $\xi_1 a_{\tau-1}$ from and adding $\xi_1 a_{\tau-1}$ to the right side of the above equation,

$$\Delta b_\tau = \xi_0 + \xi_1(a_1 - a_{\tau-1}) + (\xi_2 - 1)b_{\tau-1} + (\xi_1 + \xi_3)a_{\tau-1} + \eta_\tau$$
$$\xi_0 + \xi_1\Delta a_\tau + (1 - \xi_2)b_{\tau-1} + (\xi_1 + \xi_3)a_{\tau-1} + \eta_\tau$$
$$\xi_0 + \xi_1\Delta a_\tau + (1 - \xi_2)\left(b_{\tau-1} - \frac{\xi_1+\xi_3}{1-\xi_2}a_{\tau-1}\right) + \eta_\tau \quad (26)$$

where, $E_{\tau-1}$ falls in [-1, 1]. The greater the absolute value of $E_{\tau-1}$, the faster the quantified values of children's mental toughness returns to the normal state with the elapse of time.

The proposed error correction model involves three terms: the fluctuation Δb_τ of b_τ, the fluctuation Δa_τ of a_τ, and the equilibrium error $E_{\tau-1}$. The above formulas indicate that *Δaτ and Eτ-1 jointly determine Δbτ*. The meaning of Δa_τ should be defined according to the actual changes of such factors as the number of cycles for sports perseverance intervention, the type of physical exercise, the presence/absence of teacher accompaniment, etc. $E_{\tau-1}$ depicts how much the quantified values of children's mental toughness under sports perseverance intervention deviate from equilibrium in the short term.

Finally, this paper establishes a breakpoint regression model for children's mental toughness variation under sports perseverance intervention. The grouping variable can be expressed as the following indicative function U_i:

$$U_i = \begin{cases}1, a_i \geq w \\ 0, a_i < w\end{cases} \quad (27)$$

If an explanatory variable a_i is more significant than threshold w, U_i=0; if a_i is smaller than w, U_i=1. In the latter case, U_i goes through discontinuous changes. If the discontinuous changes only occur to a_i and b near the breakpoint, then the variation of b must be driven primarily by a_i. The breakpoint is located at threshold w. Let A-w be the movement of the explanatory variable A of the explained variable B to the zero point; λ be the coefficient of the grouping variable U. Then, the regression function of the breakpoint regression model can be expressed as:

$$B = \gamma_s + \lambda U + \theta_k(A - w) + (\theta_q - \theta_k)U(A - w) + \eta$$
$$w - g \leq A \leq w + g \quad (28)$$

Model (28) is restricted within a distance of g from either side of w. If g is small, the fitted curve can be approximately regarded as linear, and the linear fitting approach can be adopted. If the regression equation is not symmetric about the breakpoint, then the two equations must differ in slope. This difference needs to be tolerated for the interactive term. Let θ_k and θ_q be the slope of the regression equation on the left and right of point w, respectively. Then, this paper builds $(\theta_q$-$\theta_\tau)U(A$-$w)$ based on linear function and binary variable U and treats it as the interactive term that ensures the slope difference of linear function across point w, making the linear function smoother.

4. Experiments and Results Analysis

This study fits three ARIMA models, namely ARIMA (1,1), ARIMA (1,0), and ARIMA (0,1). It conducts intervention model fitting and residual series white noise tests on the time series of the measured values of children's mental toughness under sports persistence intervention. Table 1 contains the test results for white noise on the residual series. Whether the latency is five or ten, the p-value of all three ARIMA models was significantly more significant than the critical value, showing that all three pass the white noise tests. In other words, with a substantial degree of accuracy, the three models matched the time series of

the quantifiable values of children's mental toughness under sports perseverance intervention. The minimum information requirements for various models were comparable (AIC and BIC). The ARIMA (1,0) model had reduced AIC and BIC values than the other two models. Consequently, this model was chosen for fitting.

Table 1

White noise test results on the residual series

Models		ARIMA (1,1)	ARIMA (1,0)	ARIMA (0,1)
P-value	5 lags	0.9685	0.8596	0.9528
	10 lags	0.7258	0.758	0.8216
Minimum information criterion AIC value		1472.62	1485.26	1452.12
Minimum information criterion BIC value		1485.225	1495.214	1485.254

Note: AIC and BIC are short for Akaike Information Criterion and Bayesian Information Criterion, respectively.

The original data were collected from February to July 2018 via mental toughness tests administered to kids at a primary school in Suzhou, Jiangsu Province, southeastern China. Based on these data, our sports tenacity intervention model was developed and utilized to predict the data from February to July 2019 and calculate the relative error between expected and actual values during the prediction period (Table 2).

Table 2

Prediction results of the intervention model

Time	February 2019	March 2019	April 2019
Actual value	6.8594	7.2815	8.5721
Predicted value	6.4827	6.9843	9.0234
Relative error	0.3767	0.2972	-0.4513
Time	**May 2019**	**June 2019**	**July 2019**
Actual value	6.9823	5.8263	5.6847
Predicted value	7.3426	6.5129	5.5174
Relative error	-0.3603	-0.6866	0.1673

According to Table 2, the relative error between actual and predicted values was minimal, indicating that our sports perseverance intervention model can accurately explain the time variable of the measured values of children's mental toughness. The model for the time series of the quantitative values of children's mental toughness cannot adequately assess the intervention of many elements in developing children's mental toughness under the influence of sports persistence intervention. Fortunately, the suggested intervention model can elucidate the intervention effect and mechanism and correctly anticipate the trend of children's mental toughness under sports perseverance intervention.

The trace test results and maximum characteristic root test results of the residual time series for the quantifiable values of children's mental toughness under the sports persistence intervention are presented in Tables 3 and 4, respectively.

Table 3

Trace test results on the residual time series

Number of cointegration relationships	0	1	2	3	4	5
Characteristic root	0.742851	0.682135	0.274851	0.182437	0.143295	0.051273
Trace statistic	186.2842	108.2914	45.28175	26.47231	13.92468	4.28617
P-value	0.0001	0.0263	0.0495	0.0429	0.0916	0.0826

Table 4

Maximum characteristic root test results on the residual time series

Number of cointegration relationships	0	1	2	3	4	5
Characteristic root	0.782465	0.618248	0.274129	0.183492	0.162873	0.058216
Trace statistic	82.18245	58.36274	26.48237	18.72648	14.29187	3.18246
P-value	0.0002	0.0006	0.4285	0.2761	0.1628	0.0829

The most significant number of multi-factor cointegration relationships in the time series of the quantifiable values of children's mental toughness under sports persistence intervention is recorded in the cointegration relationships

column. At the 5% significance level, there were no more than three cointegration relationships, assuming the null hypothesis was accepted. Consequently, there are three cointegration relationships between the five influencing factors, namely the number of cycles for the sports perseverance intervention, the type of physical exercise, the organizational form of physical exercise, the duration of each physical exercise, and the presence/absence of teacher accompaniment. Table 5 displays the regression coefficient statistics for each factor.

Table 5

Statistics on regression coefficients after normalizing the cointegration equation

	Normalization coefficient	Standard deviation	t-statistic
B_{i-1}	1.0002	1.0013	None
$Ln(A2_{i-1})$	-4.251746	3.256412	-1.45281
$Ln(A3_{i-1})$	16.50263	5.24712	2.85471
$A4_{i-1}$	-19.25481	2.21635	4.26581
$A5_{i-1}$	-13.25462	*None*	-3.26548

The Johansen tests for cointegration demonstrate that the measured values of children's mental toughness have a long-term equilibrium relationship with the five contributing variables. If the relationship has a short-term deviation, the proposed error correction model should fix the divergence so that the relationship returns to its initial state.

Our error correction model is founded on the cointegration tests of Johansen. Consequently, the delay order is the post-difference order, meaning that the lag equals five. The coefficients of the model incorporating three cointegration connections are presented in Table 6.

Table 6

Statistics on the coefficients of error correction model

	Correction coefficient	Standard deviation	t-statistic		Correction coefficient	Standard deviation	t-statistic
$E_{1,\tau=1}$	-0.075214	0.21546	-0.52863	$U(A1(-1))$	-0.182738	0.15385	-0.62284
$E_{2,\tau=2}$	0.042746	0.05758	0.52816	$U(A1(-2))$	0.031572	0.14228	0.27237
$U(B(-1))$	0.831526	0.18246	4.57298	$U(A1(-3))$	0.258273	0.12594	2.18138
$U(B(-2))$	-0.648294	0.37296	-2.68195	$U(A1(-4))$	-0.047374	0.11012	-0.38274
$U(B(-3))$	0.475295	0.17293	2.38589	$U(A2(-1))$	-8.362643	13.24847	-0.66275
$U(B(-4))$	-0.162863	0.24825	-0.86175	$U(A2(-2))$	-25.184829	11.13863	-1.64834
	Correction coefficient	**Standard deviation**	**t-statistic**		**Correction coefficient**	**Standard deviation**	**t-statistic**
$U(A2(-3))$	2.628574	16.12835	0.25937	$U(A4(-1))$	3.572859	2.528647	1.63728
$U(A2(-4))$	14.23859	17.19447	0.92758	$U(A4(-2))$	0.638728	2.371864	0.35327
$U(A3(-1))$	-0.06728	4.51618	-1.78386	$U(A4(-3))$	2.362586	2.37596	1.43365
$U(A3(-2))$	-1.362748	4.237594	-0.436752	$U(A4(-4))$	-0.682736	2.65737	-0.36157
$U(A3(-3))$	-5.182758	4.627854	-1.37472	$U(A5(-1))$	-2.473759	4.62795	-0.63534
$U(A3(-4))$	6.479264	4.483875	1.27538	$U(A5(-2))$	-1.682539	5.82647	-0.43278
	Correction coefficient	**Standard deviation**	**t-statistic**		**Correction coefficient**	**Standard deviation**	**t-statistic**
$U(A5(-3))$	-12.378847	4.71826	-2.48275	$U(A5(-4))$	2.546811	4.75213	0.59683

After logarithmic and differential treatment, the proposed error correction model's goodness-of-fit might reach 0.845571. This indicates that our model is an excellent fit for the measured values of children's mental toughness. Moreover, both AIC and BIC were minimal, with respective values of 3.2451 and 4.2183. Consequently, the model may accurately depict the mistake repair circumstance.

The breakpoint map of the quantitative values of children's mental toughness is depicted in Figure 1. It can be seen that the measured values increased, which is proof of the breakpoint effect of various sports perseverance levels on children's mental toughness.

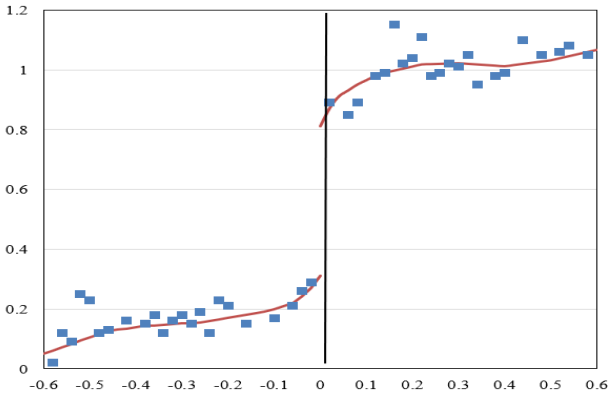

Figure 1. Third-order function fitting results of the breakpoint regression model

Table 7

Correlations between the stages of sports perseverance intervention and the cultivation of children's mental toughness

	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}
x_1	1	-0.258	-0.163	-0.153	-0.284	-0.226	-0.258	-0.425	-0.163	-0.258	-0.135
x_2		1	0.162	0.164	0.147	0.251	0.235	0.183	0.164	0.152	0.327
x_3			1	0.114	0.251	0.342	0.162	0.284	0.316	0.249	0.163
x_4				1	0.262	0.286	0.015	0.146	0.258	0.158	0.147
x_5					1	0.2548	0.327	0.185	0.2538	0.158	0.249
x_6						1	0.315	0.132	0.157	0.225	0.315
x_7							1	0.241	0.295	0.214	0.154
x_8								1	0.254	0.213	0.324
x_9									1	0.362	0.254
x_{10}										1	0.258
x_{11}											1

The correlation analysis results between the stages of sports perseverance intervention and the development of children's mental toughness are presented in Table 7. Specific stages include the unintentional stage, the intentional stage, the family support stage, the imitation stage of physical exercise behavior, the preparation stage of physical exercise behavior, the teacher assistance stage, the active participation stage of physical exercise, and the maintenance stage of physical exercise. These eight steps are designated x1, x2, x3, x4, x5, x6, x7, and x8 for clarity. In addition, the construction of confidence, concentration, and mental toughness during the development of mental toughness in children is represented by x9, x10, and x11, respectively.

According to the results of the correlation study (Table 6), there is a negative link between the inadvertent stage of physical exercise behavior and the building of confidence, concentration, and mental toughness. In contrast, the other seven stages have a positive link with building confidence, concentration, and mental toughness.

According to the aforementioned experimental findings, there are gender differences in the maintenance and deliberate stages of children's physical exercise behavior and gender and grade differences in the teacher help and family support stages. It is easier for children in the intentional stage of physical exercise behavior, the active participation stage of physical exercise, and the maintenance stage of physical exercise to improve their confidence, concentration, and mental toughness than it is for children in the unintentional stage of physical exercise behavior, because the former group has begun engaging in physical activity and gained the support of teachers and families. Thus, the sports perseverance mechanism correlates positively with the development of mental toughness in youth. A probable explanation is that youngsters who have begun and become accustomed to physical activity tend to be active, live a colorful life, have a positive outlook on learning and energy, and handle pressure effectively.

5. Conclusions

This research focuses primarily on cultivating mental toughness in youngsters through the intervention of a sports perseverance mechanism. The outcomes of this study serve as

a theoretical reference and enlightenment for future researchers, as well as a contribution to domestic research theories on this topic. In practice, these findings will consistently assist youngsters in developing an excellent mental state, inform them of the significance of physical exercise, and enable them to continue a physically active lifestyle. Building an analysis model for sports perseverance intervention in the context of children's mental toughness and performing a multi-factor cointegration test on the time series of the quantified values of children's mental toughness under sports perseverance intervention is the first step in the cultivation of children's mental toughness under the intervention of sports perseverance mechanism. Next, an error correction model and a breakpoint regression model were developed to determine when time series stray from the equilibrium state and return to normal. Then, three ARIMA models, namely ARIMA (1,1), ARIMA (1,0), and ARIMA (0,1), were utilized for the model fitting test and residual series white noise test about the time series of the quantitative values of children's mental toughness in response to sports persistence intervention.

The actual values from February to July 2019 were compared to the model's projected values throughout the experiments. The relative errors between the two sets of values indicate the model's efficacy. In addition, the trace and maximum characteristic root tests were applied to the residual time series for the quantitative importance of children's mental toughness due to the sports perseverance intervention. The test results reveal that there are no more than three cointegration relationships if the null hypothesis is not rejected. After normalizing the cointegration equation, the regression and error correction model coefficients were presented. The correlations between the stages of sports persistence intervention and the cultivation of children's mental toughness were studied. The pertinent results demonstrate the model's fit with the measured values of children's mental toughness.

Due to the limitations imposed by objective settings, this research explores just the impact of sports on the psyche and behavior of a single individual. The lack of subject diversity makes statistically significant grouping analysis impossible, limiting the research's depth. Consequently, future research will enlarge the sample size and investigate the psychological effects of various sports on various sorts of youngsters.

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