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The Effect of Physical Activity on the Non-cognitive Ability of Adolescents: An Empirical Study on Big Five Personality Traits and Large Sample Data of CFPS 2020

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Abstract: Based on the Big Five personality trait dimensions of non-cognitive ability measures, the CFPS 2020 database was used as the basis, The self-answered questionnaires and messages were collected from the people under the age of 18. And information on physical activity were selected as the study sample from the total 28590 samples in this database, among which 1562 valid samples were used as the study subjects. And the corresponding options and answers were selected as the dependent variables related to the Big Five personality like responsibility, agreeableness, extraversion, and neuroticism. After constructing a model with logit regression and calculating the marginal effects, it empirically demonstrated that increasing the frequency of physical exercises (frequency) had positive effects on promoting or improving adolescents' sense of responsibility, agreeableness, extraversion, and neuroticism, the frequency of physical exercise (frequency) in the past 12 months was used as the dependent variable, the effects were different between urban and rural areas, age, and gender. There were differences between urban and rural areas, age and gender.
Keywords: physical activity, non-cognitive abilities, Big Five personality, CFPS, social integration

1. Introduction

A strong youth predicts a strong nation [1], and a strong physical body of young students is the

human foundation that supports the rising of a strong nation. In 2018, the World Health Organization (WHO) launched a new global physical activity initiative, More Active People for a Healthier World, which describes the current prevalence and trends of physical inactivity among adolescents and youth aged 11-17 years in schools in countries and regions around the world. A new target of a 15% relative reduction in the global prevalence of physical inactivity among adolescents and adults by 2030 was proposed [2]. The overall trend of "gradual improvement" was reported by the Ministry of Education of the People's Republic of China in 2021, in which the rate excellently increased by 6.5 percentage points from 26.5% in 2016 to 33% at present, and the proportion of overweight and obese students and the proportion of poor visual acuity in each school section has been decreasing year by year [3]. From official activities or media reports, we can see that the role of physical exercise in "strengthening the body" and "improving performance" is often mentioned, but the situation is different in "strengthening the heart" and "building the soul"? "Soul building" and other functions that are not easy to be found and measured, such as promoting the quality of youth's will, social interaction, social integration, and etc, are rarely mentioned. Physical activity has multiple social values and may have positive effects on both the cognitive and non-cognitive abilities of individuals, and investing in youth physical activity is an investment in the future of the country [4]. Based on the existing theory and literature, this study further analyzes the effect of frequency of physical activity on non-cognitive abilities in adolescents.

2. Literature Review

The previous studies related to the effects of physical activity on adolescents' cognitive abilities and academic performance can be traced back to the 1950s. And after the 20th century, a number of remarkable research results have emerged under the influence of theories and research methods related to cognitive neuroscience [5]. For the relationship between physical calcination and non-cognitive abilities, there are two main aspects: one is the influence of non-cognitive abilities on children's participation in physical calcination, such as sports and personality [6], the influence of personality traits on physical activity participation [7], and the relationship between physical activity and mental health [8]; the other is the influence of physical activity on what? the study of the effects and mechanisms of adolescents' non-cognitive abilities has recently drawn scholarly attention [9],[10],[11].

Non-cognitive abilities were first proposed by economists Bowles and Gintis in 1976, who argued that individuals' abilities can be divided into cognitive and non-cognitive abilities, while non-cognitive abilities have an important impact on individuals' academic achievement and earnings in the labor market [12].And non-cognitive skills include personality traits, such as emotional stability, reliability. In the economics literature, personality traits are often referred to as non-cognitive abilities, and this trait can be distinguished from intelligence. Kyllonen classified non-cognitive abilities into the following categories: personality, broad attitudinal dispositions, social axioms and beliefs, attitudes toward school, personal interests, personal self-evaluation, cultural constants, values, subjective well-being, economic (social, time, risk) preferences, emotional intelligence, and mood, among others [13]. Poropat conducted a meta-analysis of studies examining personality and academic performance by using the Five Factor Model (openness, responsibility, extraversion, agreeableness, and neuroticism) and found that responsibility, openness, and agreeableness were significantly related to academic performance, and that the strength of the correlation between responsibility and academic performance was similar to that between Intelligence Quotient (IQ) and academic performance. he also found that adding responsibility as an independent influencer increased the prediction of subsequent college academic performance while controlling for the same high school academic performance variables, and that responsibility had as much incremental predictive power as IQ for college academic performance [14],[15] . There are multiple non-cognitive skills (e.g., attitudes, values, beliefs, and behaviors) also referred to as 21st century skills, social-emotional skills, or interpersonal and self-reflective skills that will play or may play an important role in academic and work success [14].

It shows that non-cognitive abilities possess plasticity [16], and among the many factors that affect adolescents' non-cognitive abilities, the importance of physical exercise is self-evident [17]. In the growth process of adolescents, physical exercise can not only improve their physical quality but also their ability to adapt to society, such as through self-expression, mutual cooperation and emotional control [7]. Based on CEPS data, we analyzed the effects of physical activity on

adolescents' non-cognitive abilities, the path of differences [10], and some other studies found that the improvement of adolescents' non-cognitive abilities reverses the promotion of physical activity behaviors. Combined with the theory of planned behavior (TPB), Courneya and her colleagues found that conscientiousness and extraversion personality traits had a positive effect on physical activity behavior, whereas neuroticism had a negative effect on physical activity behavior [18].Bowman found that personality traits such as extraversion and emotional stability were positively related to physical activity motivation, whereas openness was negatively related to physical activity motivation [19].Through a meta-analysis Wilson and Dishman noted that non-cognitive abilities were positively correlated with physical activity behavior in a low degree [20]. To conclude, the importance of noncognitive abilities has been confirmed by a growing number of studies. Based on this, certain metrics have been developed, which laid the foundation for this study.

3. Data and Model

3.1 Data source

The data for this study were obtained from the China Family Panel Studies (CFPS) database of individual-level questionnaire statistics for the year of 2020. The survey interviewed 14,960 households and 42,590 individuals, and conducted a long-term follow-up survey on the individual sample, which is the first large-scale, comprehensive and academically-oriented social tracking survey project in China. And CFPS2020 has a total of 28,590 individual questionnaire data information [21]. Combined with the purpose of this paper, therefore, the samples of the self-answering questionnaire mode in the database, in which the information of age under 18 years old, frequency of physical exercise without null value, and each physical exercise lasting more than 10 minutes were selected. Thus a total of 1648 observed samples were obtained, and after removing the invalid responses among variables and samples that have missed variables, 1562 samples were actually obtained, which is the basic data of this study.

3.2 Independent and dependent variables

Independent variable

In the CFPS2020 questionnaire, there are two main options related to physical activity, namely "QP701N Frequency of physical activity in the past 12 months (times)" and "QP702N Time spent per exercise (minutes)". The frequency of physical exercise (times) was set on a scale of 1-7 from low to high for each of the past 12 months and weekly frequency (times).

Dependent variable

This study focused on the effects of physical activity on noncognitive abilities, and the measurement of noncognitive abilities was based on the Big Five personality traits which were widely used in psychology [22]. According to the Big Five personality, the five major components that make up personality are: neuroticism, extraversion, open-mindedness, agreeableness, and responsibility. Neuroticism is a personality dimension that describes a person's nervousness, anxiety, disappointment, and restlessness, and it is a major source of negative affect. The higher the value of this indicator, the lower the subject's tolerance for stress and the more likely he or she is to feel stressed, depressed, and depressed. Extraversion describes a person who is outgoing, energetic, energetic and helpful, and it is a personality dimension of self-confidence. Open-mindedness refers to the ability to be creative and curious. And higher values of this measure indicate a high level of curiosity and a tendency to seek out and accept new experiences and novel ideas or concepts [23]. The personality dimensions of friendliness, gentleness, warmth, cooperation, and trust are described as desirable, and individuals with high desirability have stronger motivation to have close relationships. Responsibility describes individuals who are confident, focused, efficient, and organized [24]. Referring to a similar study [25], four dimensions of the Big Five personality model, namely, agreeableness, responsibility, extraversion, and neuroticism, were selected to be examined from the question items that were highly correlated with non-cognitive abilities based on the options provided in the questionnaire. In the setting and selection of variables, "QN10024 Trust in strangers" was selected for the dimension of agreeableness, "KR4302 Absence from school in the last month" was selected for the dimension of responsibility, and "QM2011 Personality" was selected for the dimension of extraversion. The score of "QM2011 How good is the relationship with people (score)" was selected; the score of "QN406 Number of days of feeling depressed in the past week" was selected for neuroticism.

3.3 Control variables

The respondents' urban and rural areas, gender, age, health status and mode of interview, and what were used as control variables. The names and meanings of the independent, dependent, and control variables are shown in Table 1.

Table 1：Variable Table and Meaning

Variables	Question & Meaning	Variable value	Variable type
sp_p	QP701N Frequency of physical exercise in the past 12 months (times)	1. Less than once a month on average; 2. More than once a month on average, but less than once a week; 3. 1-2 times a week on average; 4. 3-4 times a week on average; 5. Five or more times a week on average; 6. Once a day; 7. Twice or more a day;	Independent variables
Trust	QN10024 Trust degree to strangers	0-10 points； 0 points for very distrust, 10 points for very trusting dependent variables.	dependent variables
Truancy	KR4302 Have you ever been absent from class in the last month	1Yes; 0 No	
Friendship	QM2011 How good is the popularity relationship (score)	0-10，0 represents the lowest, 10 represents the highest	
Sprit	QN406 Frequency of feeling depressed in the past week (days)	1. Most of the time (5-7 days) 2. Frequently (3-4 days) 3. Sometimes (1-2 days) 4. Few (less than a day)	
Urb	Urban and rural classification based on the data of the National Bureau of Statistics	1 urban；0 village	control variables
Ask	Ask & answer mode	1 telephone interview; 0 Interview	
Gender	QA002 Gender	1 Male; 2 Female	
Age	WA001B Age	9-18	
Health	QP201 Health Condition	5. Very healthy 4. Very healthy 3. Relatively healthy 2. General 1. Unhealthy	

Data source: This study is organized according to CFPS2020

After assigning values to each volume according to the rules in Table 1, the descriptive statistics of variables using Stata17 software are shown in Table 2.

Table 2: Descriptive statistics of variables

Variable	N	Mean	p50	SD	Min	Max	Range
sp_p	1562	3.828	4	1.407	1	6	5
trust	1562	2.412	2	2.041	0	10	10
truancy	1562	0.00900	0	0.0930	0	1	1
friendship	1562	7.017	7	1.857	1	10	9
sprit	1562	3.308	3	0.758	1	4	3
urb	1562	0.473	0	0.499	0	1	1
gender	1562	1.454	1	0.498	1	2	1
age	1562	13.84	14	2.467	10	18	8
health	1562	4.023	4	0.890	1	5	4
ask	1562	0.859	1	0.348	0	1	1

Data source: This study is organized according to CFPS2020

Table 2 reports the total sample size, the mean, median (50th percentile), variance, minimum, maximum, and range of values for each variable. As reported in Table 2, the mean value of the independent variable was 3.83, indicating that the average frequency of weekly exercise sample was between 3 and 4, corresponding to a frequency of about 3 times per week, and 50% of the sample exercised between 3 and 4 times per week; among the dependent variables, the overall trust in strangers had a mean value of 2.41 and a 50th percentile of 2, indicating that the trust in

strangers was at a low position; almost no one missed class in the past month; human relationships were all at a level of 7 or higher; the mean value of low mood in the past week was between 1-2 days; the sample was about half urban and half rural; there were slightly more females than males in the sample; the overall health level was above very healthy; and the sample was mainly questionnaires which were completed by telephonic interview.

3.4 Model

The dependent variables in this study are all discrete variables. The regression with traditional OLS will have bias, so logit, which is specifically used for pinning discrete dependent variables, is chosen for regression analysis. The dependent variable truancy is a 0-1 type variable, so the binomial logit regression model is chosen; the dependent variables trust, friendship, and spirit are ordered discrete variables, so the ordered logit regression model is chosen. The model is constructed as follows (1)

$$Result = \alpha + \beta sp\_p + \gamma Xi + \mu i \quad (1)$$

Result denotes the dependent variables (corresponding to the label names in Table 2 as trust, truancy, friendship, and spirit, respectively), the independent variable is denoted by sp_p, and the control variable is denoted by x, while β is the parameter to be estimated for the dependent variable and γ is the parameter to be estimated for the control variable.

The coefficients of logit regression for discrete dependent variables are different from those of OLS linear regression, and the coefficients reported below in this study are expressed as follows: after logit regression for discrete dependent variables, the marginal effect is calculated by finding the partial derivatives, and the marginal effect can be interpreted as the probability that a one-unit change in some independent variable causes a change in the dependent variable when other variables remain constant. The sign indicates the direction of its effect. For ordered discrete dependent variables, in addition to this interpretation, predictions can be made for the probability interval of each variable, all of which are interpreted in this study as their marginal effects.

4. Result Analysis

(1)The effects and heterogeneity of exercise frequency on absenteeism among adolescents are shown in Table 3.

Table 3. Comparison of the effect of exercise frequency on absenteeism and heterogeneity among adolescents

Variable-es	General Effect	Heterogeneity						
		Urban	Village	Male	Female	Under the age of 12	The age of 13—15	The age of 16—18
sp_p	-0.227	-0.238	-0.163	-0.246	-0.166	-0.12	0.0103	-0.348
	-0.2	-0.276	-0.289	-0.217	-0.53	-0.422	-0.419	-0.29
urb	0.0189	0	0	0.05	-0.26	0.651	-0.428	-0.096
	-0.545	(.)	(.)	-0.59	-1.484	-1.271	-1.248	-0.77
ask	0.674	0.068	0	0.46	0	-0.894	0	0
	-1.05	-1.112	(.)	-1.061	(.)	-1.335	(.)	(.)
gender	-1.667**	-1.694	-1.597	0	0	-0.418	-0.423	0
	-0.767	-1.087	-1.09	(.)	(.)	-1.273	-1.244	(.)
age	0.138	0.0642	0.209	0.230*	-0.406	0.238	-0.0526	-0.885*
	-0.112	-0.155	-0.163	-0.125	-0.366	-0.783	-0.719	-0.528
health	-0.138	-0.566	0.41	0.0679	-0.992	-1.042**	0.553	0.0628
	-0.291	-0.371	-0.487	-0.322	-0.608	-0.519	-0.774	-0.419
_cons	-3.011	-0.987	-5.129	-6.564**	4.405	-1.923	-7.012	13.94
	-2.724	-3.441	-4.007	-2.835	-5.928	-9.19	-10.97	-9.215
N	1562	739	694	853	606	525	507	210
R^2								

*p< 0.1, **p< 0.05, ***p< 0.01

Table 3 reports the marginal effects of the effect of frequency of physical activity on whether adolescents are absent from school. Based on the data from this study, the overall regression effect shows that the effect of physical calcine on whether they are absent from school is not significant at more than 95% confidence level when other variables are held constant, based on existing research which shows that exercise promotes children's executive functions (i.e., the processes needed to select, organize, and appropriately initiate goal-directed actions). Exercise may prove to be a simple and important way to enhance those aspects of children's mental functioning that are critical to cognitive development [26]. However, in terms of marginal utility, each 1-unit increase in the frequency of physical activity, i.e., 1 increase in the frequency of physical activity per week, would decrease the probability of absenteeism among adolescents by 22.7%, specifically for urban students the probability would decrease by 23.8%, rural students by 16.3%, males by 24.6%, females by 16.6% and at a 95% confidence level significant, and for students aged 16-18 years, the decrease was 34.8%.

For other variables, such as health status, if all other variables are kept constant, each year of age will reduce the probability of absenteeism by 13.8% overall, especially at the age of 9-12, which will reduce the probability by 104% and it is significant at the 95% level, so it can also be inferred that physical health status is an important factor affecting absenteeism.

(2)The effects and heterogeneity of adolescents' exercise frequency and trust in strangers are shown in Table 4.

Table 4. Comparison of the effects and heterogeneity of exercise frequency and trust in strangers among adolescents

Variab-les	General Effect	Heterogeneity						
		Urban	Village	Male	Female	Under the age of 12	The age of 13—15	The age of 16—18
sp_p	0.0224	0.03	0.012	-0.013	0.0609	0.0769	0.0285	-0.0117
	-0.0323	-0.0468	-0.0449	-0.0436	-0.0485	-0.057	-0.0522	-0.0616
urb	0.0565	0	0	0.217*	-0.129	-0.0644	-0.0804	0.369**
	-0.0914	(.)	(.)	-0.124	-0.136	-0.165	-0.146	-0.173
gender	-0.161*	-0.321**	-0.00389	0	0	-0.196	-0.2	-0.16
	-0.0905	-0.132	-0.125	(.)	(.)	-0.163	-0.145	-0.171
age	0.318***	0.350***	0.290***	0.307***	0.334***	0.400***	0.316***	0.0949
	-0.0199	-0.0292	-0.0273	-0.026	-0.0308	-0.104	-0.0885	-0.103
health	-0.109**	-0.154**	-0.0539	-0.124*	-0.0871	-0.303***	-0.0503	0.0478
	-0.0514	-0.0717	-0.0741	-0.0694	-0.0771	-0.0898	-0.0836	-0.1
N	1562	739	823	853	709	525	600	437
R2								

*p< 0.1, **p< 0.05, ***p< 0.01

Table 4 reports the marginal effects of adolescent physical activity frequency on whether adolescent students trust strangers. Overall, when other variables are held constant, each 1-unit increase in physical activity frequency, which means an increase of 1 physical activity frequency per week, increases the probability of adolescents' trust in strangers by 2.24%, and more specifically, for urban students the probability will increase by 3%, rural students by 1.2%, a decrease of 1.3% probability for boys, an increase of 6.09% probability for girls, an increase of 7.7% probability for those under 12 years old, an increase of 2.85% probability for the 13-15 years age group , and a decrease of 1.17% probability for 16-18 years old. It is noteworthy that for other variables, such as age, when other variables are held constant, the probability of increasing trust in strangers increases by 31.8% for each year of age, peaking at about 12 years of age at 40%, significant at the 99% level, and decreasing to 9.5% under 16-18 years of age. This indicates that trust is easily developed with age and the process of social interaction and integration.

(3)The effects of adolescent exercise frequency on personhood and heterogeneity are shown in Table 5.

Table 5. Comparison of the effect of exercise frequency on personhood and heterogeneity among adolescents

Variab-les	*General Effect*	*Heterogeneity*						
		Urban	Village	Male	Female	Under the age of 12	The age of 13—15	The age of 16—18
sp_p	0.0896***	0.138***	0.0464	0.0589	0.126***	0.0247	0.102*	0.211***
	-0.0323	-0.047	-0.0448	-0.0439	-0.048	-0.0546	-0.053	-0.0629
Urb	-0.0319	0	0	0.0731	-0.153	-0.0957	0.0342	-0.0597
	-0.0908	(.)	(.)	-0.123	-0.135	-0.157	-0.148	-0.174
Ask	-0.0147	-0.117	0.076	-0.0563	0.0604	-0.053	-0.115	0.176
	-0.13	-0.206	-0.17	-0.177	-0.194	-0.219	-0.202	-0.274
gender	-0.217**	-0.325**	-0.105	0	0	-0.121	-0.247*	-0.315*
	-0.0897	-0.131	-0.124	(.)	(.)	-0.155	-0.146	-0.172
Age	-0.0125	0.00794	-0.0314	-0.00703	-0.0179	-0.169*	0.132	-0.0756
	-0.0185	-0.0265	-0.0259	-0.0246	-0.028	-0.0979	-0.0888	-0.104
health	0.365***	0.349***	0.390***	0.358***	0.394***	0.209**	0.328***	0.715***
	-0.053	-0.0742	-0.076	-0.0704	-0.0815	-0.0877	-0.0869	-0.107
N	1562	739	823	853	709	525	600	437
R2								

$^{*}p< 0.1$, $^{**}p< 0.05$, $^{***}p< 0.01$

Table 5 reports the marginal effects of adolescent physical activity frequency on personhood.In general, for every 1 frequency unit increase in physical activity frequency, i.e., 1 increase in weekly physical activity frequency, the probability of adolescent personhood improvement increases by 8.96% and at 99% significant level. More specifically, urban students will increase by 13.8% probability, rural students by 4.6% probability, male students by 5.9% probability, 12.6% probability increase for female students and at 99% significant level, 2.47% probability increase for under 12 years old, 10.2% probability increase for 13-15 years old age group and at 90% significant level, and 21.1% increase for 16-18 years old and at 99% significant level. It can also be seen that for other variables, such as health status, when the other variables are held constant, the probability of each level of health increases, the probability of a level of sense of kinship increases by 36.5% and significant at the 99% level.And the stage of 9-18 shows a fast rate of increase, from 21% at the age of 9-12 years to 71.5% at the age of 16-18, and also the significance level increased from 90% to 99%.

(4)The effects of exercise frequency on mood and heterogeneity among adolescents are shown in Table 6.

Table 6. Comparison of the effect of exercise frequency on mood and heterogeneity among adolescents

Variab-les	General Effect	Heterogeneity						
		Urban	Village	Male	Female	Under the age of 12	The age of 13—15	The age of 16—18
sp_p	0.00699	-0.00167	0.00783	-0.022	0.0302	0.0173	-0.0451	0.0536
	-0.0348	-0.0512	-0.048	-0.0471	-0.0523	-0.0595	-0.0566	-0.0674
Urb	0.112	0	0	0.298**	-0.101	0.2	0.0645	0.0417
	-0.0989	(.)	(.)	-0.135	-0.147	-0.17	-0.16	-0.19

Ask	-0.291**	-0.331	-0.259	-0.0934	-0.513**	-0.337	-0.256	-0.282
	-0.141	-0.216	-0.187	-0.189	-0.212	-0.237	-0.222	-0.293
gender	-0.236**	-0.462***	-0.0526	0	0	-0.0732	-0.431***	-0.194
	-0.098	-0.145	-0.134	(.)	(.)	-0.169	-0.159	-0.188
Age	-0.00682	-0.0162	0.000999	0.00695	-0.0252	0.0131	-0.0615	-0.0258
	-0.0201	-0.0291	-0.0279	-0.0267	-0.0305	-0.107	-0.0975	-0.114
health	0.204***	0.268***	0.147*	0.192**	0.222***	0.184**	0.278***	0.128
	-0.0557	-0.0784	-0.0802	-0.0747	-0.0847	-0.0911	-0.0923	-0.111
N	1562	739	823	853	709	525	600	437
R2								

*p< 0.1, **p< 0.05, ***p< 0.01

Table 6 reports the marginal effects of adolescent physical activity frequency on mood. In general, for each increase in physical activity frequency by 1 frequency unit, i.e., an increase in physical activity frequency by 1 time per week, the probability that adolescent's low mood will decrease by 2-3 days per week increases by 0.7%.More specifically, urban students will decrease by 0.17% probability, rural students by 0.78% probability, male students by 5.9% probability, and a 3% probability increase for girls, a 1.73% probability increase for those under 12 years of age, a 4.5% probability decrease for the 13-15 age group with a 90% significance level, and a 5.3% increase for those 16-18 years of age. When other variables held constant, the probability of having a better mood increases by an average of 20.4% for each level of health status and is significant at the 99% level. It is more so for girls, towns, and 13-15 years old, with corresponding probabilities of 22.2%, 26.8%, and 27.8% and significant at the 99% level.

5. Robustness Testing

5.1 Co-linearity detection

In the empirical regression analysis, the model estimation is distorted or difficult to be estimated accurately due to the existence of exact correlation or high correlation between the independent variables and control variables. So the covariance analysis is done on the independent variables and control variables. And if the absolute value of the correlation coefficients between the respective variables and control variables is less than 0.3, the correlation is generally considered not to exist or considered to be very low. The results of covariance detection of independent and control variables with Stata17 software are shown in Table 7.

Table 7. Correlation coefficient matrix between independent and control variables

Variables	(1)	(2)	(3)	(4)	(5	(6)
(1) sp_p	1.000					
(2) urb	0.014	1.000				
(3) ask	0.054	0.040	1.000			
(4) gender	-0.048	-0.003	-0.005	1.000		
(5) age	-0.020	0.004	0.049	0.009	1.000	
(6) health	0.043	-0.027	-0.001	-0.035	-0.164	1.000

Table 7 reports the variational correlation coefficient matrix. And the absolute values of the correlation coefficients between the independent variables and the control variables are all much smaller than the constant postal judgment criterion of 0.3, so there is no covariance between the independent variables and the control variables, and the regression results are valid.

5.2 Instrumental variables regression

The model stability was tested by constructing an instrumental variable as a new independent variable to be substituted into the model for regression, and constructing the instrumental variable sp_ln, sp_ln=ln(exercise frequency*time per exercise), which is the approximate total exercise time by multiplying "exercise frequency" and "time per exercise", taking the natural logarithm of

the total exercise time for smoothing and substituting into the regression model, and the marginal utility coefficients of the two regressions are shown in Table 8.

Table 8. Comparison table of marginal utility coefficients from regression of instrumental independent variables

Variables	Truancy		trust		friendship		sprit	
	sp_p	sp_ln	sp_p	sp_ln	sp_p	sp_ln	sp_p	sp_ln
sp_p	-0.227	-0.342	0.0224	0.0248	0.0896***	0.146**	0.00699	0.0000126
	-0.2	-0.332	-0.0323	-0.0581	-0.0323	-0.0581	-0.0348	-0.0636
Urb	0.0189	0.00764	0.0565	0.0612	-0.0319	-0.0469	0.112	0.112
	-0.545	-0.547	-0.0914	-0.0918	-0.0908	-0.0912	-0.0989	-0.0993
Ask	0.674	0.689	0.334***	0.345***	-0.0147	-0.0207	-0.291**	-0.289**
	-1.05	-1.053	-0.128	-0.128	-0.13	-0.13	-0.141	-0.142
gender	-1.667**	-1.745**	-0.161*	-0.171*	-0.217**	-0.180**	-0.236**	-0.237**
	-0.767	-0.772	-0.0905	-0.0918	-0.0897	-0.0915	-0.098	-0.0998
Age	0.138	0.15	0.318***	0.318***	-0.0125	-0.0169	-0.00682	-0.00687
	-0.112	-0.113	-0.0199	-0.0199	-0.0185	-0.0185	-0.0201	-0.0201
health	-0.138	-0.128	-0.109**	-0.106**	0.365***	0.361***	0.204***	0.204***
	-0.291	-0.291	-0.0514	-0.0515	-0.053	-0.053	-0.0557	-0.0558
N	1562							
R2								

*p< 0.1, **p< 0.05, ***p< 0.01

After the regression of the instrumental independent variables reported in the sink table in Table 8, the results of the regression and the original independent variable results maintain the direction of influence and are basically consistent in the degree of influence, which indicate that the regression model is stable and feasible.

6. Discussions, Conclusions and Recommendations

6.1 Discussions

① Based on the present study (see Tables 3-6), increasing the frequency of physical activity in adolescents had a positive contribution to adolescents in terms of responsibility, agreeableness, extraversion, and neuroticism. Increased levels of physical activity have a significant effect on reducing depression, anxiety, psycho-logical distress, and emotional distress in children [8]; physical activity has a facilitative effect on adolescents' self-regulation, social competence, self-confidence, and self-efficacy, and a decreasing effect on negative emotional experiences [9], and any level of physical activity, including low levels (e.g., walking 150 min/week), may prevent future depression [27], and regular physical activity (PA) and higher cardiorespiratory fitness may reduce stress responses and thus help to reduce stress-related risk factors [28]. Specifically for this study, overall, increasing the frequency of physical activity once a week would decrease the probability of school absenteeism by 22.7%, increase the probability of trusting strangers by 2.24%, increase the probability of improving people skills by 8.96%, and increase the probability of reducing depressed mood by 2-3 days per week by 0.7% among adolescents.

② For a long time, due to various factors such as differences in natural environment, cultural traditions, economic development levels between regions and value preferences of the education policy system, the development of primary and secondary school sports in China has been very unbalanced between regions, urban and rural areas, and schools. Especially the development of rural primary and secondary school sports lags behind and has a large gap compared to urban primary and secondary school sports [29]. It also found that rural junior high school students significantly lagged behind their urban peers in the development levels of multiple non-cognitive abilities such as self-efficacy, self-confidence, self-regulation, sociality, positive emotions, and self-education expectations [30]. In a comparison of the utility for urban and rural adolescents, each increase in the frequency of physical activity by 1 time per week had a utility for urban

adolescents that was 2 percentage points higher than overall in reducing the probability of absenteeism and about 1 percentage point higher than overall in trusting in strangers, and nearly 5 percentage points higher than overall in improving the probability of being likeable, that is, increasing the frequency of physical activity by 1 time per week for adolescents in urban adolescents had a positive effect on the utility of responsibility and agreeableness. And extroversion is better than that of rural adolescents. Education authorities should establish a linkage and coordination mechanism to improve the quality of rural physical education, promote the development of physical education in rural schools, narrow the urban-rural gap, and promote the social integration of rural adolescents with physical exercise activities.

③The development of non-cognitive skills in physical activity showed some group differences: girls performing better than boys in non-cognitive skills [11]. And for both male and female adolescents, increasing physical activity by 1 time per week would be 8 percentage points more effective in reducing the probability of absenteeism for males than for females, and about 8% more effective in trusting strangers for females than for males, and 6.7 percentage points more effective in improving people skills for females than for males. The effect of increasing the frequency of physical activity was 6.7 percentage points higher for females than for males, and the effect of reducing the number of bad mood days per week was 2.9 percentage points higher for males than for females. That is, as the frequency of physical activity increases, male adolescents have higher utility than females in terms of responsibility and improvement of bad mood, while female adolescents have higher utility than male adolescents in terms of agreeableness and extroversion. Physical exercise can be used to develop responsibility and suppress bad mood in male adolescents and to promote social trust and social integration in female adolescents.

④ Regarding each age stage, the influence mechanism of physical activity differed from primary to junior high school stages [31]. The age range of the sample in this study was 9-18 years old, which basically corresponds to the elementary school stage (9-12 years old), middle school stage (13-15 years old), and high school stage (16-18 years old) according to the current compulsory education children's enrollment age and school system. The utility of increasing the frequency of physical exercise by 1 time is higher in reducing the probability of absenteeism at the elementary school stage and high school stage than at the middle school, and high school stage was 34.8% highest and 12% at the elementary stage; in terms of trusting in strangers, there was a boost in both elementary and middle school stages, with elevated probabilities of 7.69% and 2.85%, and a reduction of 1.17% at the high school stage; in terms of people skills there was a significant boost at the elementary stage, middle school stage, and high school stage, with elevated probabilities of 2.47%, 10.2%, and 21.1%; in terms of utility of reducing bad mood 2-3 days per week, both elementary school stage and high school stage are positive, with probability scores of 1.73% and 5.36%, respectively, while middle school stage is negative, but increases the probability to 4.51%. Is it possible to launch that the elementary school stage and middle school stage are easy to build trust through physical exercise and easier to integrate into society, but the utility decreases after high school stage tends to be independent? Is it understandable that physical exercise is significant in improving people's skills as they get older, and that as the frequency of physical exercise increases, it is easier to gain recognition, find confidence, and achieve better social integration? In terms of improving bad moods, do adolescents experience negative effects of physical activity instead because of the pressure of physical exams at the junior high school level?

6.2 Inspiration

Theoretical and applied studies have confirmed the importance of non-cognitive skills, which play a very obvious and normal role in people's learning and working lives, and in the field of educational reform, "emotions, attitudes and values" is one of the three-dimensional objectives of the curriculum reform. writing, scientific knowledge, etc., should focus on the education of students' non-cognitive skills so as to promote the overall development of young children and adolescents. And studies have been conducted to emphasize that in order to promote sustainable development, the importance of physical activity must be kept in mind when designing the curriculum of educational institutions [32]. On January 1st, 2023, the Law of the People's Republic of China on Physical Education came into effect and it declared that "schools shall include extracurricular physical activities for students conducted on school premises in their teaching plans, articulate them with the content of physical education classes, and guarantee that students participate in no less than one hour of physical exercise every day while at school" [33]. Since the

Ministry of Education of the People's Republic of China introduced physical education curriculum standards, in September 2022, all grades of nine-year compulsory education schools nationwide are required to offer physical education and health classes, which account for 10%-11% of total class time, second only to language (20%-22%) and mathematics (13%-15%), As some scholars have said, it is a very meaningful decision to allow children to increase physical activity at this stage [34].On the basis of existing studies, this study empirically demonstrated the utility of increasing the frequency of physical activity for adolescents in terms of responsibility, agreeableness, extraversion, and neuroticism, and explored the value of physical activity for adolescents, which has some practical value. Meanwhile, in response to the differences in utility between urban and rural areas, age, and gender, different modes of instructional work can be targeted to different groups.

6.3 Limitations

This paper also has some limitations, On the one hand, in the selection of dependent variables, in the setting and selection of variables, the selection of "QN10024 trust in strangers", "KR4302 whether or not you have missed class in the last month", "How good is the human relationship (score) QM2011", "Number of days QN406 felt emotionally depressed in the past week", and then using this as a dimension to examine the Big 5 personality and non-cognitive abilities, which may not be very comprehensive; on the other hand, in the model regression, the paper uses the model to derive the direction of impact and the marginal effect of impact influence, providing the probability of possible occurrence, but the degree of impact is not reflected in the regression, and the guidance for practical work cannot accurately predict the relationship of quantity; thirdly, this study only discussed the marginal effect of 1 increase, and the effect of continued increase and the inflection point have not been analyzed in depth.

6.4 Conclusions

As young people are the hope of the country and the future of the nation, this study recommends that schools and families strictly implement the relevant provisions of the Physical Education Law of the People's Republic of China, and that young students "participate in at least one hour of physical activity every day during the school day" .When children participate in the recommended 60 minutes of moderate to vigorous physical activity per day, they can achieve a variety of physical and mental health benefits [35],[36]. Increasing the frequency of physical activity for young students guides the majority of young students to have fun, enhance their physical fitness, improve their personalities, refine their will, and promote physical and mental health and all-round development in sports.

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