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Tracking study of physical fitness evaluation indicators for children and adolescents aged 12-15 in China under the background of "integration of physical education"

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Abstract: *It is a consensus among scholars at home and abroad that a good level of physical fitness has a positive impact on adolescents' physiological and psychological health. Adolescent physical health indicators are not only related to the risk of cardiovascular diseases, but also play an important role in improving adolescents' academic performance. Adolescent physical health indicators are not only related to the risk of cardiovascular diseases, but also play an important role in improving adolescents' academic performance. Identifying changes in adolescent physical health indicators is not only conducive to Identifying changes in adolescent physical health indicators is not only conducive to understanding their health status, physiological characteristics and individual differences, but also can provide a basis for adolescent talent identification and triage. Changes in the physical fitness of adolescents continue to improve with their age, and there are significant gender differences in the changes. Changes in the physical fitness of adolescents continue to improve with their age, and there are significant gender differences in the changes. In the age group of 12-13 years, males show a more significant rate of development in speed, aerobic and strength than females . This study is to track the physical fitness indicators of 12-15 year old adolescents in China, and to evaluate the stability of the changes in the indicators at different testing nodes of adolescents. This study is to track the physical fitness indicators of 12-15 year old adolescents in China, and to evaluate the stability of the changes in the indicators at different testing nodes of adolescents, with a view to providing reference for the improvement of the evaluation standard of physical fitness of adolescents in China, the reform of school physical education curriculum, and the establishment of students' physical fitness and health records. The following is a summary of the findings of the study.*

Keywords: *children or adolescents; physical fitness; motor development; stability*

1. Objects and methods of study

1.1 Subject of the study

It is the common understanding of scholars at home and abroad that a good physical health level has a positive impact on the physical and psychological health of adolescents. Physical health indicators of adolescents are not only related to the risk of cardiovascular diseases, but also play an important role in the improvement of adolescent academic performance[1-2]. It is not only helpful to understand the state of health and physiological characteristics of adolescents, but also to provide the basis for identifying and diverting adolescents [3]. The changes of physical fitness of adolescents will continue to improve with the growth of their age, and there are significant gender differences in the changes. At the age of 12 to 13 years old, males show more obvious development speed than females in speed, aerobic and strength.[4]

Based on the principle of stratified sampling[5] , taking some adolescents in Province S as an example, one junior high school was selected in each provincial capital city, general city, prefecture-level city, and township, and one class in each grade of each school was randomly selected as the sampling unit for the three stages of follow-up tests over a period of three school years. Of the 653 (328 males and 325 females; the study excluded 338 samples that failed to participate in all tests) who participated in all four follow-up tests from the first test in the 2016-2017 school year, 315 (167 males; 148 females) were used as group 1 (LC 1), which accounted for 48.2% of the initial sample size

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in 2016-2017 (50.9% of males; female 45.5%).

The 343 (172 males; 171 females) of the 702 (360 males and 342 females; the study excluded 359 samples who failed to participate in all tests) new enrollees in 2017-2018 who participated in all three follow-up tests were included as group 2 (LC 2), which accounted for 48.9% of the total sample size of new enrollees in 2017-2018 (47.8% of males; female 50%).(Sees the table 1)

Table 1: Basic Information of Subjects (M±SD)

Age delineation	Gender	*N*	2016/2017 Average age	*N*	2017/2018 Average age	*N*	2018/2019 Average age	*N*	2019/2020 Average age
12-12.9	Male	328	12.6±0.34	285	12.5±0.38				
	Female	325	12.5±0.35	293	12.4±0.36				
13-13.9	Male			360	13.6±0.68	267	13.8±0.53		
	Female			342	13.6±0.52	272	13.8±0.51		
14-14.9	Male					320	14.7±0.58	246	14.5±0.69
	Female					304	14.7±0.54	241	14.4±0.71
15-15.9	Male							203	15.5±0.41
	Female							189	15.6±0.44
aggregate		653	12.6±0.45	1280	13.1±0.71	1163	14.3±0.75	879	15.1±0.92

1.2 Research methodology

1.2.1 Screening of test indicators

In this study, we first analyzed the physical fitness assessment systems of children and adolescents in foreign countries in the past 20 years[6-8] to provide theoretical support for the screening of the testing index system. Secondly, after initially determining the testing indexes[9-11] and proving their validity through prediction tests, the study seeks the opinions of domestic and foreign experts related to physical fitness and health research as well as relevant practitioners who have been engaged in students' physical fitness and health testing for a long period of time. Finally, we designed and completed the "Screening Questionnaire on Physical Fitness Evaluation Indicator System for Children and Youth"[12-14] , which adopts Satty's 9-level scale method to categorize the survey contents into 5 levels, namely, absolutely important, very important, relatively important, a little important, and equally important, corresponding to the scores of 9, 7, 5, 3, and 1, respectively. A questionnaire survey was conducted among the professionals and technicians above deputy senior level who are engaged in the field related to the physical health of adolescents, 40 questionnaires were distributed by e-mail, 40 questionnaires were recovered, and 39 questionnaires were valid, and the experts' evaluation of the questionnaire on the screening and determination of the test indexes accounted for 82.5% of the total number of very satisfied, and 15% of the total number of comparatively satisfied.

1.2.2 Test methods and processes

1.2.2.1 Human morphology, physical fitness tests

The physical fitness test index for children and adolescents contains nine items[15-17] : height, weight, BMI, 20 m round-trip running, curls, vertical jump, 50 m running, sitting forward bending, 10×5 return running. Among them, height, weight, 50 m running according to the "National Physical Fitness Monitoring" rules for testing, BMI using the body mass index formula BMI = weight (kg) ÷ height ² (m) to complete. The requirements for the rest of the tests are as follows:

1) 20m round trip run. The test requires the participant to run continuously between 2 markers at a distance of 20 m in intermittent round trips at an increasing speed and cadence. The increasing speed is indicated by an audio signal from the software. The starting speed of the test is 8.5 km-h^{-1} , increasing by 0.5 km-h^{-1} per minute (1 minute equals 1 level). Subjects are expected to complete as much distance as possible during the test, and two consecutive fouls or inability to keep up with the tempo will end the test, and the final score will be the level completed and the corresponding Vo_2 max.[18-20] . 20-m round-trip run. Maximum oxygen uptake is estimated using the Leger formula[21-23] : Vo_{2max} = 31.025 significant change + significant change (3.238 significant change x significant change velocity) significant change - significant change (3.248 significant change x significant change age significant change) significant change + significant change (0.1536 significant change x significant change age

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significant change x significant change) completion. velocity) completed.

2) Vertical longitudinal jump. Choose (Tongfang CSTF-ZT vertical jump tester), technical parameters: range: 0-100cm, index value: 0.1cm, error: ±1%. The distance between the feet and the ground after the subject jumped with arms in place (the knee joints should be straight after jumping) was taken as the final score[24-26] .

3) Seated forward bending. The (Ranchi TZCS-3) seated body forward bending tester was used for the test. When preparing for the movement, the tester sits on a flat floor or mat, with the buttocks, back, shoulders and back of the head close to the wall, arms straight, palms facing down with both hands placed on the surface of the test instrument, and both legs straight. At the beginning of the test, the upper body bends forward to push the test instrument slowly forward until it can not be pushed forward until the test instrument, record the performance in cm[27] .

4) Belly Roll Test. Subjects lie flat on their backs with the soles of their feet parallel to the floor, knees bent at approximately 90°, hands on either side of the body, fingertips of both hands need to touch the knee joints as they rise and return to the starting position, completing as many repetitions as possible to record the subject's final score[28] .

5) 10×5m Tumbling Run. Adopt the American-made (Brower Timing systems speed tester): in the designated starting line using standing start, the subject with the dominant foot standing next to the TC-Motion sensor (starter), ready to run on their own, the accuracy of the time for 0.01s. 10 × 5m meter return test requires athletes to start in front of two parallel lines 5m apart, from the starting line to the second line as best as possible to repeat the return run, at least one foot must exceed the parallel line to be valid, the total distance of 50m, record the final results. The test requires the athlete to run in front of two parallel lines 5m apart, from the starting line to the second line to do his/her best to run back repeatedly, at least one foot must be over the parallel lines to be valid, with a total distance of 50m, and record the final score[29-30] .

1.2.2.2 Test quality and process control

This study adopts the principle of stratified sampling[31-33] . This study is based on the "2010 Sixth National Population Census Main Data Bulletin" issued by the National Bureau of Statistics in 2011, which guarantees the scientific and reasonable sampling ratio in four aspects, namely, the ratio of men to women, the ratio of people from the South to the North, the ratio of ethnic groups, and the ratio of people from towns to villages.

After the research testing process and research methodology were reviewed for ethics and morality, the classroom teachers of each sampled class were given specialized training in procedures and monitoring. The relevant administrators of the schools to which all subjects belonged were aware of the intention of the test and signed an informed consent form. The day before the test, the subjects were free of athletic injuries and high-intensity exercise, and the relevant personnel were informed of the purpose and process of the test in advance before the test and asked the subjects to complete the test according to the requirements, and the test process was carried out in accordance with the unified operational norms, standards and procedures to ensure the accuracy of data collection, Validity[34] .

1.2.3 Mathematical processing and statistical methods

The study was conducted using SPSS 24.0 for data processing and the results were expressed as mean ± standard deviation ($M \pm SD$) with significant difference set at ($P<0.05$). To quantify stability, Pearson's correlation coefficient was used to calculate the stability of the different testing time points with respect to the changes in each physical fitness indicator. Repeated measures analysis of variance (rmANOVA) was used to present significant changes in physical fitness indicators over time and the interaction of time and gender.

2. Findings

2.1 Overall results of the tracking test of physical fitness indicators for children and adolescents in each cohort

The results of the study showed that, except for the indicators of sitting forward bending and 20m round-trip running, all the physical fitness test indicators of adolescents in the LC1 and LC2 groups showed different degrees of increase with their age.(Sees the table 2,the table 3,the table 4)

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Table 2: Results of Physical Fitness Tracking Test in longitudinal cohort 1 (LC1) N=315

		2016/2017	2017/2018	2018/2019	2019/2020
Test metrics	Gender	(12.4±0.3years)	(13.6±0.5years)	(14.7±0.5years)	(15.5±0.4years)
		Mean ± s	Mean ± s	Mean ± s	Mean ± s
20m-round trip (mL-kg-1-min-1)	Male	49.8±5.3	50.4±6.7	50.2±6.5	51.1±5.4
	Female	45.6±4.7	45.1±5.1	43.8±5.4	43.0±4.3
roll-ups (number of times)	Male	33.8±5.3	35.4±6.2	38.9±6.4	39.8±6.3
	Female	29.1±5.6	28.8±5.5	31.2±5.2	32.4±5.8
vertical jump (centimeters)	Male	33.2±3.9	35.6±4.4	37.8±4.1	39.7±4.5
	Female	28.8±4.1	30.9±4.9	33.2±3.7	33.7±4.7
50m dash dash (seconds)	Male	8.8±0.5	8.0±0.4	7.8±0.4	7.5±0.4
	Female	9.5±0.4	9.1±0.5	9.0±0.3	8.8±0.5
sit-up-and-bend (physical exercise) (centimeters)	Male	18.8±5.5	17.4±6.7	18.6±7.3	16.2±6.9
	Female	23.9±5.9	22.5±6.2	24.5±6.8	23.1±6.1
10×5m folding (seconds)	Male	19.0±2.0	17.9±2.3	18.2±2.0	17.6±2.8
	Female	20.5±2.1	19.6±2.4	20.3±2.6	20.0±1.9
BMI (kg-m)$^{-2}$	Male	21.2±3.1	21.9±3.3	22.4±3.4	23.2±3.6
	Female	20.7±2.4	21.2±2.1	21.4±2.8	22.7±2.7

Table 3: Results of Physical Fitness Tracking Test in longitudinal cohort 2 (LC2) N=343

		Academic year 2017/2018	Academic year 2018/2019	Academic year 2019/2020
Test metrics	distinguishing between the sexes	(12.5±0.4years)	(13.5±0.5years)	(14.7±0.6years)
		Mean ± s	Mean ± s	Mean ± s
20m-round trip (mL-kg-1-min-1)	male	52.4±5.5	53.1±5.7	52.0±5.3
	daughter	44.2±5.1	46.2±5.4	45.0±4.6
roll-ups (number of times)	male	32.7±5.9	34.8±5.6	35.2±6.3
	women	28.6±6.1	28.2±6.3	29.1±5.7
vertical jump (centimeters)	male	31.9±4.1	34.1±4.5	36.2±3.6
	daughter	28.1±3.8	29.8±4.2	32.5±3.2
50m dash dash (seconds)	male	8.6±0.6	8.3±0.5	8.1±0.5
	daughter	9.2±0.4	9.0±0.7	8.8±0.6
sit-up-and-bend (physical exercise) (centimeters)	male	17.6±5.8	17.0±6.1	17.0±6.6
	daughter	23.2±5.4	24.8±6.8	23.8±6.3
10×5m dash (seconds)	male	18.9±2.0	18.7±2.2	18.4±2.5
	daughter	20.4±2.1	20.2±2.3	20.1±2.4
BMI (kg-m)$^{-2}$	male	21.5±2.8	21.4±2.4	22.3±3.1
	women	21.0±2.2	21.1±2.3	22.0±2.9

Among them, the trend of significant decrease in the indicator of seated forward bending with age in the LC1 group was mainly concentrated in boys. In contrast, the decrease in maximal oxygen uptake with age was mainly observed in girls. In addition, significant changes in the interaction between time of testing and gender were also observed in the LC2 group for seated body flexion and vertical jump, with girls generally having higher seated body flexion than boys, and boys having more significant changes in vertical jump. In the LC1 group the boys showed significant changes in the curls and vertical longitudinal jump indexes at all different testing time points compared to the female athletes.

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Table 4: rmANOVA results for longitudinal cohort 1 (LC1) and longitudinal cohort 2 (LC2)

Test metrics	Group (starting time)	effect size	*F*=	*P*=	Eta $=^2$
20m round-trip run Vo_2 max (mL-kg-1-min-1)	LC1 (2016)	time	72.35	<0.01	0.235
		sex	18.50	<0.01	0.073
		time*sex	7.28	<0.01	0.691
	LC2 (2017)	time	118.45	<0.01	0.346
		sex	33.58	<0.01	0.073
		time*sex	2.06	0.35	0.003
roll-ups (number of times)	LC1 (2016)	time	223.21	<0.01	0.485
		sex	0.610	0.55	0.002
		time*sex	11.5	<0.01	0.282
	LC2 (2017)	time	123.64	<0.01	0.361
		sex	0.31	0.54	0.001
		time*sex	4.58	0.06	0.013
vertical jump (centimeters)	LC1 (2016)	time	215.88	<0.01	0.479
		sex	2.14	0.23	0.007
		time*sex	0.12	<0.01	0.001
	LC2 (2017)	time	185.54	<0.01	0.323
		sex	4.56	0.13	0.012
		time*sex	1.07	<0.01	0.005
50m dash dash (seconds)	LC1 (2016)	time	554.23	<0.01	0.679
		sex	6.13	0.04	0.032
		time*sex	0.67	0.43	0.004
	LC2 (2017)	time	436.93	<0.01	0.584
		sex	7.15	0.04	0.025
		time*sex	0.27	0.65	0.001
sit-up-and-bend (physical exercise) (centimeters)	LC1 (2016)	time	8.83	<0.01	0.034
		sex	23.75	<0.01	0.065
		time*sex	7.63	<0.01	0.031
	LC2 (2017)	time	3.11	0.023	0.005
		sex	30.13	<0.01	0.076
		time*sex	6.22	0.02	0.015
10×5m dash (seconds)	LC1 (2016)	time	658.46	<0.01	0.753
		sex	8.59	<0.01	0.033
		time*sex	0.14	0.97	0.000
	LC2 (2017)	time	963.78	<0.01	0.858
		sex	4.96	0.09	0.019
		time*sex	1.59	0.23	0.004
BMI $(kg\text{-}m)^{-2}$	LC1 (2016)	time	195.63	<0.01	0.475
		sex	1925.86	0.11	0.073
		time*sex	0.03	0.85	0.000
	LC2 (2017)	time	84.50	<0.01	0.251
		sex	1.85	0.33	0.006
		time*sex	2.96	0.07	0.012

Note: Effect sizes include the interaction effects of test time, gender and test time with gender.

3. Discussion

In this study, we examined the physical fitness indexes of the general adolescents aged 12-15 years old in China by tracking test, and screened the changes of each test index. The results of the study showed that, except for seated forward bending and maximal oxygen uptake, the physical fitness indicators of adolescents in the LC1 and LC2 groups showed different degrees of improvement with age; the stability coefficients of the changes in the adolescents' physical fitness indicators showed a slight decrease with age, and the stability correlation coefficients of the changes in the physical fitness indicators of the male adolescents were higher than those of the female adolescents.

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4. Conclusions and recommendations

4.1 Conclusion

Cyclical differences in the growth and development of adolescent boys and girls, the plateau effect of speed capacity, methodological differences in the means of testing and the intensity and frequency of participation in sports may be one of the factors influencing the development of flexibility and cardiorespiratory endurance[35] . The dynamics of changes in physical fitness indicators in adolescents as a whole is moderately stable, and the coefficient of stability of changes in indicators is higher in boys than in girls. The stability of changes in physical fitness indicators may be one of the effective indicators for predicting future trends in physical fitness and for early identification and localization of superior and inferior athletic abilities in adolescents .[36]

4.2 Recommendations

This study conducted tracking tests and monitoring of physical fitness indicators of 12-15 year old adolescents in China, and analyzed the developmental changes of the indicators with age growth, which can help relevant practitioners to understand the characteristics of physical development and changes in athletic qualities of adolescents in different age groups, formulate personalized exercise prescription, improve the evaluation standard of physical fitness of adolescents in China, and promote the level of adolescents' physical fitness and health[37] .

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