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Secular trends in motor performance of children and adolescents between 2010 and 2020

Elena Schlag[1] | **Nina Ferrari**[2] | **Benjamin Koch**[3] | **Sigrid Dordel**[4] | **Christine Joisten**[5]

[1]Institute of Sports and Sport Science, Karlsruhe Institute of Technology, Karlsruhe, Germany

[2]Cologne Centre for Prevention in Childhood and Youth/ Heart Centre Cologne, University Hospital of Cologne, Cologne, Germany

[3]Bremen- City Centre of Obesity Therapy (ZABS e.V.), Bremen, Germany

[4]Institute for Sports Didactics and School Sports, German Sport University Cologne, Cologne, Germany

[5]Institute for Movement and Neuroscience, German Sport University Cologne, Cologne, Germany

Correspondence
Elena Schlag, Institute of Sports and Sport Science, Karlsruhe Institute of Technology, Engler- Bunte- Ring 15, Karlsruhe 76133, Germany.
Emails: uxzfq@student.kit.edu; Elena.schlag@t-online.de

Abstract

Over the last few years, numerous studies have proclaimed a negative trend in the motor performance of children and adolescents. Drawing from the online Fitness Olympiad database, the data of 8239 children and adolescents from Germany were analyzed by age, sex, and motor performance measured using the Dordel–Koch–test (DKT). Results were compared from the 2010-2012 and 2018-2020 cohorts. The results of the 2010-2012 and 2018-2020 cohorts were then compared regarding the general and sex-specific changes in the development of motor performance. A negative trend was shown for three of five motor performance test items, with decreases of 0.9%-4.8% in abdominal and leg strength and coordination under time pressure, respectively, being found. In contrast, endurance improved by 0.4% and arm and trunk muscle strength by 3.1%. The negative development can be seen as a correlate of exercise deficit disorder (EDD) due to increasing sedentarism. Therefore, the correlation between motor performance and health indicates a clear motivation to appropriately promote the main forms of motor activity.

KEYWORDS

health, motor skills, physical activity, secular trend

1 | INTRODUCTION

The positive role of physical activity is now undisputed. Physical benefits resulting from physical activity include body weight regulation, better bone health, and improved muscle strength and function, whereas psychological benefits include improved brain function, academic performance, and mental health.[1] However, it is concerning that three out of four adolescents aged 11-17 years worldwide do not meet the WHO's physical activity recommendations of 60 minutes of moderate-to high-intensity physical activity per day.[2] Krug et al[3] showed, in their Motorik–Modul study,[4] that almost 85% of children and adolescents in Germany do not achieve these recommendations. In addition to the possible health consequences of a lack of physical activity, there are also signs of a decline in motor skills associated with this lack. Better physical fitness is also associated with a better state of physical health in children and adolescents.[5] Analogously, a decrease in physical fitness and motor performance and an increase in sedentary behavior in children and adolescents seem to be associated with increased health risk factors, such as overweight/obesity, cardiovascular disease, orthopedic problems, or mental illness,[6] and can be seen as clinical correlates of exercise deficit disorder (EDD).[7] Adequate assessment of motor performance and its negative development is therefore the basis for designing effective and sustainable countermeasures. However, the assessment of physical fitness and motor performance is a methodological challenge since the variety of test procedures and definitions makes interpretation difficult. Thus, motor performance is one of the various terms used in the literature to encompass multiple aspects of movement skills (ie, motor skills, motor abilities, etc). This discussion will not be deepened here, but it is worth noting that studies on children's motor performance must always be read in light of the underlying definition. For example, Caspersen et al[8] distinguished health-oriented (cardiorespiratory endurance, muscle strength, etc) from skill-related components (speed, power, etc) of physical fitness or motor performance, respectively. For this analysis, we used the definition of Bös,[9] in which motor performance was differentiated into energetically determined conditioning and information-oriented coordinative abilities (see Table 1). In recent years, many reviews have been published on the various facets of motor performance. The central point thereof will be briefly presented below.

Based on shuttle-run tests, Tomkinson and Olds[10] demonstrated an annual decline in aerobic performance of 0.36%, while a recent systematic review showed a 7.3% decrease in cardiorespiratory fitness from 1981 to 2014.[11] In contrast, there was a 38.4% improvement in sit-ups from 1964 to 2017,[12] a 19.4% improvement in hand strength from 1967 to 2017,[13] and a 1.73 cm improvement in standing long jumps per decade.[14] On the other hand, Albon et al[15] analyzed studies on strength ability and showed a decrease in speed of about 0.3% on the agility test per year and in standing long jump scores of roughly 0.25% per year.

In a recent systematic review, Fühner et al[16] presented the secular trend of the various main forms of motor stress between 1972 and 2015. Regarding the cardiorespiratory endurance, there was an initial increase and a subsequent decrease between 1986 and 2010-12. In addition, measurements of relative muscle strength tended to show a slight increase, and regarding the speed, a slight to moderate increase was observed since 2002. Therefore, the changes did not show a linear increase or decrease; improvements were mostly seen until the beginning of the 21st century, after which a stabilization or decrease of the individual facets was noticed. Duric et al,[17] in Slovenian cohorts, showed that the largest negative changes (30.1%) were observed from 1993/94 to 2003/04 and the smallest negative changes (4.2%) from 2003/04 to 2013/14. Moreover, Masanovic et al[18] demonstrated a continuous decline in endurance and strength ability between 1969 and 2017. In general, the changes described were similar for girls and boys, and the improvements were more evident in younger children aged between 9 and 12 years than in adolescents aged between 13 and 17 years. Independent of the secular trend, boys performed substantially better than girls in terms of muscular strength, muscular power, muscular endurance, speed-agility, and cardiorespiratory fitness (CRF) tests but worse on the flexibility test.[19]

However, the assessment of motor competence is relevant for designing targeted countermeasures for EDD. So far, only the data of the motor module are available for Germany, in which the physical fitness or motor performance is based on the definition of Bös[9] as examined in three waves between 2003 and 2017.[20] The results showed a slight increase between 2003 and 2006 (baseline) and 2009 and 2012 (wave 1), then stagnation until wave 2 (2014-2017). However, to date, there are no further data, including real-world data or data integrated up to 2020.

Therefore, this study aimed to analyze the developmental course of motor performance in children and adolescents aged between 6 and 16 years from 2010 to 2020 using the online Fitness Olympiad database (www.fitnessolympiade.de).

2 | MATERIALS AND METHODS

The Fitness Olympiad database, with the results of the Dordel–Koch-test (DKT),[21] formed the basis of this study. Complete data sets on age, sex, and the five selected test items, namely, *lateral jumping*, *standing long jump*, *sit-ups*, *push-ups*, and *6-minute run*, from 2010 to 2012 and 2018 to 2020 were compared.

2.1 | Subjects

After cleaning the data of 21 648 children and adolescents, the dataset for analysis comprised complete information on the studied test items, age, and sex of N = 8239 ($n_{2010\text{-}2012}$ = 3893, $n_{2018\text{-}2020}$ = 4346) children and adolescents. The age range was 6.0-16.4 years (M = 9.8 ± 2.6), and 50.2% of the participants were male. When age was taken into account, 6978 subjects ($n_{2010\text{-}2012}$ = 3405, $n_{2018\text{-}2020}$ = 3573) were classified as children aged between six and 12.9 years, and 1261 subjects ($n_{2010\text{-}2012}$ = 488, $n_{2018\text{-}2020}$ = 773) aged between 13 and 16.4 years were classified as adolescents.

The data of the children and adolescents were checked for plausibility. For this purpose, cut-off values were set

10% above the norm values of Jouck[22] for each test item and served as exclusion criteria. In addition, results with a value of 0 and a value of 1 for the test item *lateral jumping*, were excluded.

2.2 | Fitness Olympiad

The basis of the DKT battery was the model of Bös.[9] It differentiates motor performance into energetically determined conditioning and information-oriented coordinative abilities. The basic level consists of the fundamental abilities of aerobic endurance, strength, speed, coordination/agility, and flexibility (see Table 1).

The Fitness Olympiad is based on the DKT battery, which consists of seven test items: *lateral jumping*, *standing long jump*, *sit-and-reach*, *sit-ups*, *one-legged stand*, *push-ups*, and *6-minute run* (see Table 1). A manual for performing the exercises is freely available on the website (www.fitnessolympiade.de). All tests should be performed barefoot, in sportswear and in a sufficiently large hall. The exception is the *6-minute run*, which should be performed with shoes. There are no instructions for motivational support in the manual.

In this analysis, those test items less prone to error were integrated. The items of this test battery were chosen based on literature research and represented the core domains of the theoretical framework of motor performance: agility, coordination, power, endurance, and speed.[9] The selected items are standardized, valid tests for testing motor performance.[21] For statements about objectivity, reliability and validity, values were taken from the work of Jouck[22] and Bös[23] (see Table 1).

The test items *sit-and-reach* and *single-legged stand* were not evaluated in this article because they are difficult for inexperienced test administrators to perform and document and may, therefore, not be comparable. For example, administrators may have problems counting ground contact occurrences. The age and (foot) size of children can also play a role, that is, the larger the sole, the easier it is to perform the exercise. Furthermore, it could be difficult for inexperienced test administrators to consistently ensure that the children's legs are extended during *sit-and-reach*. In addition, the brief holding time often makes it difficult to read the achieved value.

2.3 | Statistical analysis

The analysis was carried out using IBM SPSS Statistics 27. The years of interest—2010-2012 and 2018-2020—were extracted via filtering, and data were checked for plausibility. The significance level for all tests was 5%.

First, the arithmetic means, 95% confidence intervals (CI), and changes in percentages were determined as part of the descriptive statistics. The means of the independent variable (annual cluster) with two characteristic values were compared using a *t*-test for independent samples.

To be able to make statements about the development of motor performance of children and adolescents, the statistical procedure was again applied to the extracted annual clusters. A filter was placed over age, and participants were divided into children aged 6 to 13 years and adolescents aged 13-16 years. Further steps for statistical analysis were carried out as previously described.

To be able to make sex-specific statements, the data of the two annual clusters were then subdivided into boys and girls according to sex, and the mean values, 95% CIs, and changes in percentages were once again determined.

To determine the influence of different covariates, such as age and sex on the dependent variable (test item), a univariate analysis of variance (ANCOVA) was performed. Here, the respective test item was used as the dependent variable, and age and sex were used as covariates.

The corrected coefficient of determination, R^2, was used to interpret the ANCOVA results and the proportion of variance of the dependent variable that each factor explained. To be able to define the influence of all covariates, parameter estimation was carried out by taking the regression coefficient *b* into account.

3 | RESULTS

3.1 | Fitness test scores

3.1.1 | Lateral jumping

Boys and girls in the 2010-2012 annual cluster (n = 3774) achieved an average of 53.9 jumps (95% CI: 53.33-54.51). Jumps ranged from 2 to 106. For the 2018-2020 annual cluster (n = 4147), the average number of jumps was 53.4 (95% CI: 52.86-53.98; $P = .182$), with a range of 2-113. The percentage decrease in the number of jumps between annual clusters was 0.9%.

3.1.2 | Standing long jump

On average, children and adolescents in the 2010-2012 annual cluster jumped 121.8 cm (n = 3773; 95% CI: 120.91-122.70), with a range of 23.0-240.0 cm. For the 2018-2020 annual cluster, the mean distance was 117.6 cm (n = 4184; 95% CI: 116.70-118.47; $P < .001$), with a range

TABLE 1 Theoretical and operational definitions of motor performance (adapted from Caspersen et al, 1985; Bös, 1987; Jouck, 2008, tested on 107 children and adolescents; Bös, 2017)

Core domain	Theoretical definition	Operational definition in the DKT	Quality criteria according to Bös[29] / Jouck[22]
Agility/coordination	The ability to rapidly change the position of the entire body in space with speed and accuracy The interplay between the central nervous system and moving body parts in performing motor tasks smoothly and accurately	*Lateral jumping*: The subject jumps sideways over a line on a felt-like floor as many times as possible for 15 s. This method serves to measure whole-body coordination under time pressure, as well as speed and the strength endurance of the leg muscles. Two runs are performed, and the number of correct jumps made in 15 s is counted as the raw value.	*Objectivity* Bös: $r = .99$ *Reliability Test- Retest* Bös: $r = .89$-.96 Jouck: $r = .94$ *Validity* expert rating (grading scale): expressiveness: 2.0; feasibility: 1.6 construct validity: tested within the framework of the German motoric test
Power	The rate at which a person can perform work (strength over time)	*Standing long jump*: This exercise is used to measure take-off power. Taking off with both legs (in a parallel position with legs bent), the subject jumps as far as possible and touches down with both feet, standing firmly. Swinging of the arms is permitted. Two runs are performed, and the higher measured value is used. The raw value is the distance from the take-off line to the heel of the rear foot. *Sit-ups:* Sit-ups can be used to test the strength of the muscles of the abdomen and hip flexors. The subject lies in a dorsal position on a mat. Their feet are kept as wide apart as the hips and are planted on the floor. The knee angle should be 90 degrees. The feet are held down by another subject so that they remain in contact with the ground. The subject raises their chest until their elbows touch their knees, then they lower their chest until their shoulder blades just touch the ground. The subject should do as many sit-ups as possible in 40 s; the count is the raw value. *Push-ups:* This test is used to measure the muscles of the arms and trunk. The subject lies prone and initially keeps their hands on their buttocks. The hands are moved from the back and put down below the shoulders. Then, the subjects push themselves up from the ground until their arms are extended. One hand is now taken off the ground and touches the other hand. During this procedure, only the hands and toes are kept in contact with the ground; the trunk and legs are extended. The arms are then bent again until the body is back in the prone position. The subjects return to their initial prone position with their hands on their buttocks (clapping their hand behind their back). Correctly performed push-ups done in 40 s are counted as the raw data.	*Objectivity* Bös: $r = .95$ *Reliability: Test- Retest* Bös: $r = .82$ Jouck: $r = .80$ *Validity*[29]*:* expert rating for test items 1.31-2.5 (grading scale) confirmatory construct analysis for construct validation statistical analyses confirm the criterion- related validity *Objectivity/ Reliability Test- Retest* Bös: $r = .83$ Jouck: $r = .52$ *Validity* expert rating for test items 1.75-2.17 (grading scale) confirmatory construct analysis for construct validation statistical analyses confirm the criterion-related validity *Objectivity/Reliability Test- Retest* Bös: $r = .74$ Jouck: $r = .72$ *Validity*[29]*:* expert rating for test items 1.31-2.5 (grading scale) confirmatory construct analysis for construct validation statistical analyses confirm the criterion- related validity

TABLE 1 (Continued)

Core domain	Theoretical definition	Operational definition in the DKT	Quality criteria according to Bös[29] / Jouck[22]
Cardiorespiratory and aerobic endurance	The ability of the circulatory and respiratory systems to supply fuel during sustained physical activity and to eliminate fatigue products after being supplied with food	*Six-minute run*: The 6-minute run is used to analyze the endurance performance. This run is valid for school children and correlates with the results of treadmill testing. The subjects run 54 m in small groups (up to eight children) for 6 min. The rounds are counted to determine the exact distance covered. Performance is then evaluated depending on the distance run (in meters).	*Objectivity/ Reliability Test- Retest* Bös: $r = .92$ *Jouck:* $r = .92$ *Validity:* Criterion- related validity: correlation Shuttle Run[29]: $r = .88$ Construct validity: correlation VO_2max[30]: $r = .69$
Flexibility (data not shown)	A health-related component of physical fitness that relates to the range of motion available for a joint	*Sit-and-reach:* The subject sits on the ground and straightens their legs at a right angle against a standardized device. Then, they bend their upper body forward, moving their hands as far forward as possible. Their legs remain stretched. The heels represent the zero point of the measurement scale. Positive values are below the level of the sole, negative values refer to the area from foot to hip. The scale is read at the farthest point that the fingertips can touch, with this reading being used as the raw value.	Data not shown
Balance (data not shown)	The maintenance of equilibrium while stationary	*One-legged stand*: The subjects stand on one leg while holding on to their free foot for an extended period (static). The subjects then grasp their unsupported foot while making slow steps on the agility ladder (dynamic). The subjects then move their arms and trunk forward to pick up an empty can while standing on one leg	Data not shown
Speed	The ability to perform a movement within a short period	Not integrated	

of 8.0-240.0 cm. Thus, the distance decreased by 3.4% between the two annual clusters.

3.1.3 | Sit-ups

The mean number of repetitions of sit-ups achieved for the 2010-2012 annual cluster was 16.8 (n = 3482; 95% CI: 16.54-16.97), with a range of 1-44. For the 2018-2020 annual cluster, the mean was 16.0 repetitions (n = 3910; 95% CI: 15.79-16.20; $P < .001$), with a range of 1-40. Overall, the number of repetitions decreased by 4.8% between the two annual clusters.

3.1.4 | Push-ups

Children and adolescents in the 2010-2012 annual cluster achieved an average of 9.6 push-ups (n = 2853; 95% CI: 9.43-9.80), with a range of 1-26. Children and adolescents in the 2018-2020 annual cluster achieved 9.9 repetitions (n = 3262; 95% CI: 9.71-10.02; $P = .045$), with a range of 1-22. A percentage increase in repetitions of 3.1% between the annual clusters was detected.

3.1.5 | Six-minute run

The average distance achieved for the 2010-2012 annual cluster was 852.2 m (n = 3566; 95% CI: 845.8-858.6), with a range of 320.0-1539.0 m. For the 2018-2020 annual cluster, the mean distance was 856.9 m (n = 3986; 95% CI: 851.5-862.3; $P = .270$), with a range of 320.0-1552.0. Overall, the distance increased by 0.4% between the annual clusters.

3.2 | The proportion of variance explained by age and sex

The proportion of variance explained by age and sex was calculated. The percentage of variance explained (R^2), significance, and regression coefficient *b* are presented in Table 2.

3.3 | The development of mean values for children and adolescents

For children aged between 6 and 13 years, a significant decline was detected for four of the five items measuring motor performance. Highly significant decreases were found for the test items *lateral jumping* (3.3%), *standing long jump* (4.7%), *sit-ups* (6.4%), and *6-minute run* (2.2%). A tendency toward improvement could be seen for the test item *push-ups*, with an increase in the number of repetitions of 1.9%. A detailed presentation of the children's results is shown in Table 3.

For adolescents (Table 4) aged between 13 and 16 years, the results of all five test items examined showed a tendency toward improvement. The mean difference of the test item *lateral jumping* (4.8%) was significant ($P = .014$), and the test item *6-minute run* showed a highly significant improvement (23.1%). For the test items *standing long jump* (2.0%), *sit-ups* (1.8%), and *push-ups* (7.2%), a tendency toward improvement was recognized.

3.4 | Comparison of mean values by sex

For boys (Table 5), a negative change was found in two of the five test items examined, which was highly significant for the test item *standing long jump* (3.4%), while for the test item *sit-up* (2.3%), only a tendency of deterioration was evident. Two test items (*lateral jumping* and *6-minute run*) showed a tendency to improve, while the improvement of the test item *push-ups* could be classified as significant. For this test item, the largest and positive percentage change (4.0%) could also be calculated.

For girls (Table 6), a negative change was found for three of the five test items examined. The decrease in the distance of the test item *standing long jump* (3.8%) and

TABLE 2 Presentation of the proportion of the variance of the mean differences [R^2 in %] to be explained by age and sex as well as the significance and the regression coefficient b

	Proportion of explained variance of MW differences by R^2 [%].	Age *P*-value [regression coefficient b]	Sex *P*-value [regression coefficient b]
Lateral jumping [number of jumps]	16	<.001 [b 2.9]	.428 [b −0.3]
Standing long jump [cm]	6.6	<.001 [b 2.2]	<.001 [b −8.8]
Sit-ups [repetitions]	6.4	<.001 [b 0.6]	<.001 [b −1.5]
Push-ups [repetitions]	2.2	<.001 [b 0.2]	<.001 [b −0.7]
Six-minute run [m]	2.7	.129 [b 1.20]	<.001 [b −60.6]

TABLE 3 Presentation of mean differences with CI-interval, *P*-value and change in percent for children (6-13 years)

	2010-2012 (95% CI)	2018-2020 (95% CI)	*P*-value	Change [%]
Lateral jumping [number of jumps]	n = 3315 53.1 (52.51-53.75)	n = 3411 51.4 (50.79-52.00)	<.001	−3.3
Standing long jump [cm]	n = 3302 121.6 (120.71-122.52)	n = 3465 115.9 (115.02-116.80)	<.001	−4.7
Sit-ups [repetitions]	n = 3055 16.7 (16.46-16.90)	n = 3175 15.6 (15.40-15.83)	<.001	−6.4
Push-ups [repetitions]	n = 2513 9.7 (9.47-9.86)	n = 2589 9.8 (9.67-10.01)	.184	+1.9
Six-minute run [m]	n = 3130 870.6 (864.16-877.12)	n = 3313 851.1 (845.5-856.3)	<.001	−2.2

TABLE 4 Presentation of mean differences with CI-interval, *P*-value and change in percent for teens (13-16 years)

	2010-2012 (95% CI)	2018-2020 (95% CI)	*P*-value	Change [%]
Lateral jumping [number of jumps]	n = 459 59.6 (57.79-61.45)	n = 736 62.5 (61.07-63.87)	.014	+4.8
Standing long jump [cm]	n = 470 123.2 (119.81-126.53)	n = 719 125.7 (122.90-128.42)	.262	+2.0
Sit-ups [repetitions]	n = 427 17.3 (16.57-18.06)	n = 735 17.6 (17.10-18.15)	.496	+1.8
Push-ups [repetitions]	n = 340 9.3 (8.72-9.88)	n = 673 10.0 (9.61-10.32)	.054	+7.2
Six-minute run [m]	n = 436 719.7 (700.17-739.17)	n = 673 885.5 (869.11-901.95)	<.001	+23.1

TABLE 5 Presentation of mean differences with CI-interval, *P*-value and change in percent for boys

	2010-2012 (95% CI)	2018-2020 (95% CI)	*P*-value	Change [%]
Lateral jumping [number of jumps]	n = 1869 53.8 (52.94-54.61)	n = 2098 54.2 (53.32-54.99)	.533	+0.7
Standing long jump [cm]	n = 1871 126.4 (125.12-127.70)	n = 2121 122.1 (120.78-123.41)	<.001	−3.4
Sit-ups [repetitions]	n = 1751 17.3 (17.02-17.65)	n = 1989 16.9 (16.63-17.22)	.059	−2.3
Push-ups [repetitions]	n = 1458 9.9 (9.64-10.17)	n = 1683 10.3 (10.05-10.51)	.036	+4.0
Six-minute run [m]	n = 1774 884.4 (874.9-893.9)	n = 2027 885.2 (877.1-893.3)	.899	+0.1

the number of repetitions of the test item *sit-ups* (7.4%) are to be considered highly significant. The deterioration of the test item *lateral jumping* was very significant with a percentage change of 2.8%. A tendency of improvement could be shown for the test items *push-ups* (1.1%) as well as *6-minute run* (0.9%), but both changes were not significant.

4 | DISCUSSION

We aimed to analyze the secular trend in the development of the motor performance of children and adolescents between 2010 and 2020. In addition, the influence of age and sex on the development course of motor performance, as

TABLE 6 Presentation of mean differences with CI-interval, *P*-value and change in percent for girls

	2010-2012 (95% CI)	2018-2020 (95% CI)	*P*-value	Change [%]
Lateral jumping [number of jumps]	n = 1905 54.1 (53.23-54.90)	n = 2049 52.6 (51.77-53.33)	.009	−2.8
Standing long jump [cm]	n = 1901 117.3 (116.08-118.48)	n = 2063 112.9 (111.80-114.09)	<.001	−3.8
Sit-ups [repetitions]	n = 1731 16.2 (15.88-16.47)	n = 1921 15.0 (14.76-15.30)	<.001	−7.4
Push-ups [repetitions]	n = 1395 9.3 (9.06-9.58)	n = 1579 9.4 (9.22-9.62)	.539	+1.1
Six-minute run [m]	n = 1792 820.3 (812.0-828.6)	n = 1959 827.6 (820.7-834.5)	.185	+0.9

well as the sex-specific course of changes in motor performance, was investigated.

The results partially confirmed the negative trend proclaimed in other studies. Two strength tests, *sit-ups* (4.8%) and *standing long jump* (3.4%), showed a significant decline over the years. These findings are also reflected in the review by Eberhardt et al[24] who found a decrease in the number of sit-ups in 10 of the 18 subsamples examined from seven studies. Kaster et al[12] also identified a decline (4.1%) in repetition among more than 9 million 9-17-year-old children between 2010 and 2017. Furthermore, for the test item *standing long jump*, Fraser et al[25] examined the data on performance in the standing long jump of 11-12-year-old Australian children (N = 3732) between 1985 and 2015, finding a 11.2% decline in performance within the study period. Contrary to these findings, the results of the *push-ups* test item showed a significant improvement in performance (3.1%), which can be confirmed by studies conducted by Albrecht et al[26] between 2003-2006 and 2009-2012.

These results should be viewed cautiously because there may be deviations between the specified execution and the practical procedure. Specifically, younger children may have had problems with correct execution due to the complexity of the exercise and their lower muscle mass.[22]

In our study, endurance performance improved slightly by 0.4% over 10 years, but not significantly. Tomkinson et al[11] examined 20 m shuttle-run test results from 137 studies involving 965 264 children and adolescents between 1981 and 2014. Overall, cardiorespiratory fitness decreased by 7.3%. However, a slow stagnation of the decline could be detected since 2000. The reasons given for the constant general trend since 2000 were a stabilization in the level of physical activity and increased awareness of sedentary behavior, for example, through an increase in social marketing campaigns and political interventions.

Regarding to the influences of age and sex, it was confirmed that the investigated motor skills of strength, endurance, and coordination under time pressure increased with increasing age.[27,28] This increase can be attributed to biological development and maturation processes, hormonal changes, and social interactions.[29] With increasing age, there is also harmonization of movement sequences and an increase in intra- and intermuscular coordination.[27,30]

In addition, differences were found between boys and girls, confirming the findings of previous studies. Boys achieved significantly better results in all test items with strength and endurance components, which may be explained, on the one hand, by the hormonal conditions favoring the build-up of strength, and on the other hand, by the higher proportion of muscle in boys. However, the scope of everyday/leisure activities can also be seen as a reason for the boys' better motor performance. Krug et al[31] found a higher level of physical activity in boys than in girls (53.9% and 31.4% of girls did 90 and 180 hours of sport per week, respectively, compared with 62.8% and 45.0% of boys).

Furthermore, only two out of five test items for boys indicated a decline in motor performance over the period examined, while three test items showed a decline for girls. What was particularly striking was the decline of test item *sit-ups* of 7.4% in girls. For boys, on the other hand, the improvement for the test item *push-ups* of 4.0% represented the largest positive percentage change. Although the present study also found a decline in the performance of the test item *sit-ups* for boys (2.3%), this was smaller than for girls. For the test item *push-ups*, a significant improvement could be shown for both boys (4.0%) and girls (1.1%). Hanssen-Doose et al[20] were also able to confirm a slight tendency toward improvement for boys, but the results for girls showed a slight tendency toward decline. Endurance performance tends to improve in both boys (0.1%) and girls (0.9%), reflecting a stagnation. Comparable findings were described by Tomkinson et al[11] They described an increasingly weakening decline in aerobic performance for both boys (1.7%) and girls (0.6%) since 2000. The sex difference may also be explained by the increasing athletic participation of girls and the comparatively higher increase in body fat of boys.[24]

Overall, real-world data, as well as the results of the international literature, show a heterogeneous picture: A reduction in motor competence or physical fitness, or stagnation at a lower level, may reflect an EDD.[7] Knowledge regarding the need for support in specific areas, such as endurance or strength, etc, as well as specific target groups, such as age or sex groups, allows for the development of targeted countermeasures against EDD in different settings, for example, schools, kindergartens, etc

Our study has some strengths and limitations. To begin with, the Fitness Olympiad provides the present real-world data in an enormous, large cohort. Furthermore, the DKT battery consists of validated, reliable, and objective test items (see Table 1). Therefore, the DKT is a standardized test that addresses a wide range of fundamental movement skills. Further, its simple handling, organization, and evaluation, as well as the free access to the manual, also indicate its high levels of usefulness and economy. On the other hand, the same general methodological criticism applies to the DKT as to other tests/test batteries when it comes representing such a complex construct as "motor performance." Additionally, due to its implementation via an online platform, no statements can be made about the framework conditions for the implementation of the Fitness Olympiad. Although standardized information on the test procedure and environment can be found in the manual, it is unclear to what extent this information was implemented. Implementation by non-explicitly trained test teams, therefore, represents a weakness of the study design because this approach did not ensure standardized implementation. This issue should be considered, particularly for the results of the test items *sit-ups* and *push-ups*, because the excluded results with a value of 0 may have corresponded with valid data, especially for younger, overweight, and obese children.

5 | CONCLUSIONS

In summary, the present article's results partially confirm the proclaimed negative secular trend of the motor performance of children and adolescents in a newer timeframe. The decrease in fitness, which can be used as a surrogate parameter for EDD and a predictor of morbidity and mortality in adulthood, underlines the urgent need for the promotion of physical activity. Particularly in public institutions, such as kindergartens or schools, which are ideally suited for the acquisition of a healthy and sporty lifestyle due to the young age of the children, the focus should be on movement and physical activity because these factors positively affect motor performance. This focus should also be considered in discussions about changes to (school) policy.

CONFLICT OF INTEREST

The authors have no conflicts of interest that are directly relevant to the content of this manuscript.

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