Chapter 6

Neuromotor fitness in Dutch youth: Differences over a 26-year period (1980–2006)

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Abstract

This study aimed to compare neuromotor fitness test scores of 9–12-year-old Dutch children in 2006 with scores of same aged children in 1980. Body height, body weight and performance on neuromotor fitness test items were measured in 2,050 Dutch children from 9 to 12 years in 2006 and were compared with data of 2,603 same aged Dutch children measured in 1980 with the same neuromotor fitness test battery. Dutch 9–12 year olds in 2006 were significantly taller and heavier than their peers in 1980. Age- and sex-specific performance on almost all neuromotor fitness test items was significantly worse in 2006. Thus, our data suggest that neuromotor fitness of Dutch youth has significantly decreased over the past 26 years.

Introduction

Low physical fitness in children has been associated with impaired health indicators such as increased body fatness[1-3], several cardiovascular disease risk factors[4-6] and hypertension[1,6]. Therefore it is important to promote high levels of fitness in modern youth. Only a few studies have been published on changes in paediatric physical fitness[7]. Physical fitness can be divided into neuromotor fitness (i.e. muscle strength, flexibility, speed of movement, and coordination) and aerobic fitness. Some studies have reported that children are not currently as physically fit as their peers in the previous decades[8-10], while others report no differences[7,11,12]. Most of these studies focus on secular changes in aerobic fitness rather than neuromotor fitness. As the majority of physical activities of children involve high intensity bursts such as jumping and sprinting, a decrease in neuromotor fitness could negatively affect children in their daily physical activity levels and in the long term their health status[13,14]. In addition, because motor skill proficiency tracks through childhood[15] it is plausible that children with poorer motor skills may become less active adolescents with associated poorer fitness levels. Children who are proficient at performing motor skills may participate more in the type of activities likely to increase fitness levels. Physical activity opportunities of adolescents may thus be increased if they are competent at performing many prerequisite motor skills[16]. Therefore, neuromotor fitness may be just as important as aerobic fitness in maintaining overall health and function[17]. The few studies on secular changes of children's neuromotor fitness have shown little change in recent decades. In a systematic review, Tomkinson[13] recently analysed secular trends of performances of children (6–12 years) on power and speed tests worldwide over the period 1958–2003. Power (jumping tests) and speed test performances (sprint running and agility running tests) remained relatively stable during the whole period, but a trend towards decline was found since the 1980's (−0.08% to −0.25% per annum). Compared to secular changes in children's aerobic fitness, reported neuromotor changes are substantially smaller[10,18,19].

Since the study of Tomkinson[13] did not include data from the Netherlands, it is unknown whether secular trends in neuromotor fitness levels of Dutch youth are comparable to these documented secular changes. The present paper describes age- and sex-specific neuromotor fitness of 2,050 present Dutch children aged 9–12, using the MOtor PERformance (MOPER) fitness test. Since Leyten[20] measured MOPER fitness test performance in 2,603 Dutch children in 1980, data on changes in neuromotor fitness in Dutch youth over a 26-year period will be given.

Methods

In order to compare the MOPER fitness test scores of Dutch children in 2006 with the MOPER fitness test scores of children in 1980 permission was given to access and analyse the Leyten data[20]. The study of Leyten[20] concerned a random sample of 2,603 9–12-year-old Dutch children from 32 primary schools throughout the Netherlands. A stratified sample of regular primary schools was selected for participation, taking into account the national level of urbanisation and social status. Our study population enrolled in 2006 included 2,208 children who volunteered to participate in the iPlay-study[2] . In January 2006, 520 Dutch primary schools were randomly invited to participate in the study. Inclusion criteria for the schools were (i) being a regular primary school,(ii) giving PE classes twice a week, and (iii) willing to appoint a contact person for the duration of the study. The study population – children from 40 different primary schools in urban and suburban areas throughout the Netherlands – was a good representation of the Dutch population. The iPlay-study is a randomised controlled trial on injury prevention in Dutch primary school children, aged 9–12 years. Prior to the study, all parents of the children received an information letter by the research institute including a passive informed consent on the participation of their child(ren). The Medical Ethics Committee of VU University Medical Centre approved the study design, protocols and the passive informed consent procedure.

In this study, all injured children or children with a physical disability were excluded. In 1980, children performed all MOPER fitness test items. The MOPER fitness test includes the bent arm hang test, 10×5m shuttle run test, leg lift test, plate tapping test, sit and reach test, arm pull test and standing high jump test, and 6 min run test. In table 6.1 the outline of the MOPER fitness test items are described. For a more extensive description of the MOPER fitness test items see Kemper and Verschuur[22]. In 2006, children performed seven of the eight MOPER fitness test items. Because the iPlay-study did not focus on improvement of endurance, the '6 min run test' (aerobic fitness) was not included in 2006. Validity and reliability of the MOPER fitness test have been shown to be acceptable in children aged 9–18 years[20,23].

Trained instructors conducted all tests during a physical education class according to a standardised protocol that was the same in 1980 and 2006. Tests were performed barefoot to rule out bias by differences in footwear. Children were vocally encouraged to perform all test elements as good as possible.

Body height was measured in meters (m), to the nearest 0.01 m, with a portable stadiometer (Seca 214, Leicester Height Measure; Seca GmbH & Co., Hamburg, Germany) according to a standardised protocol. Body weight was measured in kilogram (kg), to the nearest 0.1 kg, with a digital scale (Seca 770; Seca GmbH & Co., Hamburg, Germany). During the body height and weight measurements children were dressed in underwear. From body height and body weight body mass index (BMI) was calculated to estimate overweight and obesity. Data analysis was completed using application software package SPSS 14.0. All data were stratified for age (9–12 year olds) and gender. Differences between 1980 and 2006 were assessed using t-test or Kruskal–Wallis test, depending on normal distribution. Level of significance was set at $p < 0.05$. Prevalence of overweight and obesity was calculated for the study population in 2006 using BMI and the Cole-criteria[24,25].

Table 6.1: Brief description of all MOPER fitness test items. In parentheses is the factor or ability indicated

MOPER test item	Description	Score
1. Bent-arm hang (upper body strength)	Maximal time that eyes were kept above a horizontal bar hanging in a bent arm position	sec.
2. 10 x 5 m. run (speed and agility)	Minimal time needed on a 10 times 5 m. run	sec.
3. Leg lift test (trunk/leg strength)	Lifting both legs 10 times as quickly as possible from the horizontal to the vertical with extended knees while lying	sec.
4. Plate tapping (eye-hand coordination and arm speed)	Alternatively tapping with the hand of preference as fast as possible for 25 complete cycles between two discs, of which the centres lay 75 cm.	sec.
5. Sit and reach (trunk flexibility)	Maximal reach while sitting with extended knees	cm.
6. Arm pull (static arm strength)	Maximal force pulled with preferred arm on a dynamometer while standing	kg.
7. Standing high jump (explosive leg strength)	Maximal standing vertical jump height	cm.
8. 6 minutes run (aerobic fitness)	Run a maximum distance during 6 minutes	m.

Results

All data were normally distributed, except for the scores on 'bent-arm hang' and 'leg lift test' (all age groups and both genders). As in 1980, only performance on 'arm pull' was correlated with body weight (r = 0.55) in 2006. Therefore, arm pull adjusted for weight ('arm pull adjusted' = ('arm pull'/weight)×100) was used in the analysis. In 2006, 61% of the children attended a primary school located in an urban area and 39% in a rural area. Both genders were equally represented per age category in the two groups. No differences were found per age category and gender between children living in urban and rural areas. Mean body height, body weight and BMI stratified for age and gender are shown in table 6.2. Compared to 1980, children were significantly taller and heavier in 2006 (except for height of 9-year-old boys and 12-year old girls). Prevalence of overweight and obesity in 2006 was 13% and 3% for boys and 15% and 3% for girls, respectively. Because only mean body height and body weight per age category were available from the study of Leyten[20] no individual BMI could be calculated. The estimated BMI's from the means showed a higher BMI in 2006 than in 1980 in all categories. Results on the MOPER fitness test items from 1980 and 2006 are presented in table 6.3 and figure 6.1. On all MOPER tests items for all categories (age×gender) performance was significantly worse in 2006 than in 1980, except for 'arm pull adjusted' (girls) and 'standing high jump' (boys and girls).

Table 6.2: *Mean (SD) height, weight of 9-12 year old Dutch boys and girls in 1980 and in 2006.*

	9 year		10 year		11 year		12 year		All	
	boys	**girls**	**boys**	**girls**	**boys**	**girls**	**boys**	**girls**	**boys**	**girls**
1980										
N	332	414	436	449	440	408	80	44	1288	1315
Body height cm	140	139	145	144	149	150	152	153	145	145
	(6.2)	(6.5)	(6.4)	(6.7)	(6.7)	(7.7)	(7.8)	(8.6)	(n.a.)	(n.a.)
Body weight kg	31.9	31.9	34.6	35.2	37.6	39.3	41.0	42.7	35.3	35.7
	(4.6)	(5.6)	(5.4)	(6.3)	(6.3)	(7.7)	(8.2)	(8.9)	(n.a.)	(n.a.)
BMI#, kg./m²	16.3	16.6	16.6	17.0	16.9	17.5	17.9	18.3	16.7	17.1
2006										
N	51	53	361	370	447	509	152	108	1010	1040
Body height cm	141	142	146	146	151	152	154	155	149	150
	(5.9)	(7.0)*	(6.6)*	(7.1)*	(6.9)*	(7.2)*	(7.8)*	(7.9)	(7.7)	(8.1)
Body weight kg	35.8	36.0	36.9	38.3	41.5	42.5	43.8	46.2	39.9	41.0
	(6.2)*	(7.2)*	(7.2)*	(8.0)*	(8.9)*	(8.7)*	(10.2)*	(11.3)*	(8.8)	(9.1)
BMI, kg./m²	17.9	17.7	17.2	17.8	18.1	18.2	18.4	19.0	17.8	18.1
	(2.5)	(2.8)	(2.5)	(2.9)	(3.1)	(2.9)	(3.2)	(3.4)	(2.9)	(3.0)

Asterisks indicate significant difference between 1980 and 2006 ($p < 0.05$); n.a. not available. # Estimated BMI calculated from mean body height and mean body weight per age category. BMI = Body Mass Index.

Figure 6.1: *Mean differences in performance on MOPER fitness test items of 9-12 year old Dutch boys and girls between 1980 and 2006 (1980 = 100).*

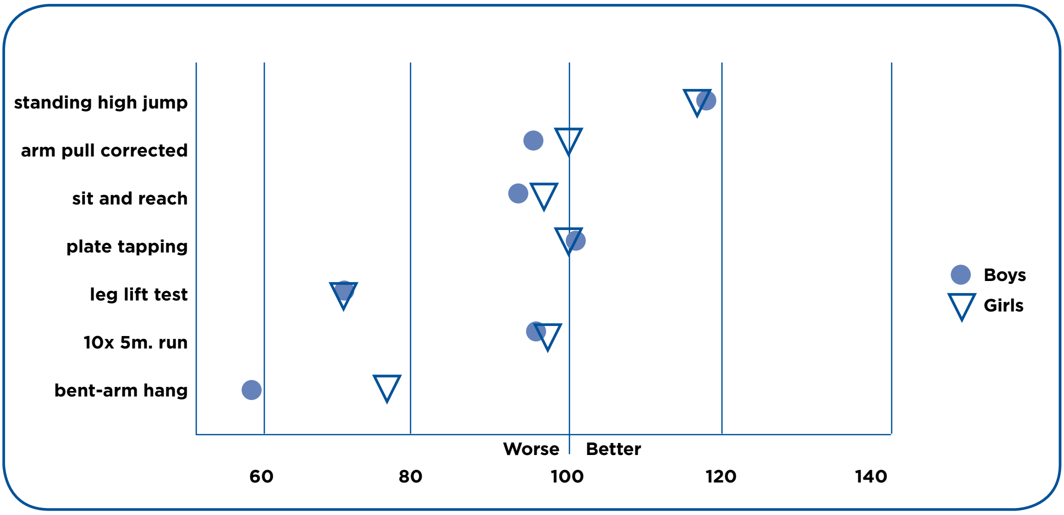

Table 6.3: *Mean scores (SD) on the MOPER fitness test items in 9-12 year old Dutch boys and girls in 1980 and 2006.*

	9 years				10 years				11 years				12 years#			
	boys		girls		boys		girls		boys		girls		boys		girls	
	1980	2006	1980	2006	1980	2006	1980	2006	1980	2006	1980	2006	1980	2006	1980	2006
Bent-arm hang, sec.	18.3 (14.6)c	10.0 (9.6)	11.9 (10.8)a	9.9 (12.9)	21.5 (16.9)c	12.9 (12.1)	11.6 (11.6)b	9.7 (10.5)	24.4 (18.4)c	12.5 (12.1)	13.0 (11.4)c	8.8 (9.4)	24.4 (18.6)	13.7 (12.0)	9.5 (7.6)	8.0 (7.9)
N	332	51	414	53	436	356	449	370	438	444	408	504	80	152	44	108
10 x 5m. run, sec	19.2 (1.1)c	20.2 (1.9)	19.9 (1.1) c	20.9 (1.8)	18.7 (1.0) c	19.7 (1.5)	19.6 (1.2) c	20.1 (1.5)	18.4 (1.0) c	19.4 (1.6)	19.0 (1.0) c	19.8 (1.5)	18.4 (1.3) c	19.2 (1.5)	19.0 (0.9) c	19.8 (1.6)
N	332	50	414	52	436	361	449	366	440	442	407	503	78	151	44	108
Leg lift test, sec	14.2 (2.3) c	18.0 (5.6)	13.8 (2.1) c	17.8 (6.2)	14.1 (2.1) c	17.9 (6.4)	13.9 (2.3) c	17.3 (4.9)	14.1 (2.3) c	18.4 (6.7)	13.7 (2.1) c	18.0 (6.9)	14.7 (2.8)	18.2 (7.1)	14.3 (1.7)	18.4 (6.6)
N	332	49	409	50	421	356	437	365	425	433	402	504	78	145	41	104
Plate tapping, sec	16.5 (2.0)	16.0 (1.7)	15.9 (1.8)	16.1 (2.4)	15.3 (1.8)a	15.6 (1.8)	14.7 (1.7) c	15.2 (1.8)	14.2 (1.7) c	14.8 (1.7)	13.7 (1.4) c	14.4 (1.7)	13.6 (1.5) a	14.1 (1.9)	13.8 (1.8)	14.1 (1.7)
N	332	50	413	53	436	357	449	364	439	441	407	508	80	151	44	107
Sit and reach, cm	28.4 (5.8)	28.1 (7.3)	30.7 (5.7) b	28.4 (6.1)	27.6 (6.0)	27.0 (6.4)	30.3 (5.7)	30.3 (6.0)	27.6 (5.9) c	25.4 (6.8)	31.7 (6.0) c	30.2 (6.2)	27.8 (6.4) a	25.5 (7.1)	32.3 (5.6) b	29.1 (6.7)
N	332	51	413	53	436	359	448	370	440	440	407	499	80	152	44	108
Arm pull adjusted, kg./kg. weight	70.2 (13.4)c	59.9 (15.4)	61.3 (14.3)	59.3 (13.1)	71.2 (14.0)	69.3 (14.9)	61.8 (13.0)	63.6 (13.1)	74.9 (14.1) c	69.5 (14.6)	61.8 (12.3)	61.2 (13.0)	75.9 (14.9) a	70.6 (14.9)	59.3 (10.6)	61.8 (12.9)
N	332	47	413	51	436	276	448	270	438	378	407	405	79	126	44	93
Standing high jump, cm.	30.9 (4.6)	34.2 (6.3) c	30.6 (4.6)	34.9 (7.1) c	32.7 (5.2)	36.8 (5.7) c	31.5 (4.7)	35.8 (6.3) c	34.2 (4.8)	38.7 (6.6) c	33.6 (4.7)	37.2 (6.3) c	35.7 (4.8)	39.7 (6.5) c	34.8 (4.6)	37.4 (6.4) b
N	332	50	413	52	436	358	448	369	437	444	406	505	77	152	44	108

Asterisks indicate significant better performance; a= $p < 0.05$; b = $p < 0.01$; c = $p < 0.001$;
Since data on 'bent-arm hang' and 'leg lift test' for 12 year olds were not normally distributed in 1980 and individual scores were not available, differences in performance could not be statistically tested.

Table 6.4. *Median scores on 'bent-arm hang' and 'leg lift test' in 9-12 year old Dutch boys and girls in 1980 and 2006.*

	9 years				10 years				11 years				12 years#			
	boys		girls		boys		girls		boys		girls		boys		girls	
	1980	2006	1980	2006	1980	2006	1980	2006	1980	2006	1980	2006	1980	2006	1980	2006
Bent-arm hang	15	7	10	7	17	9	9	6	21	9	10	6	-	10.5	-	6
Leg lift test	13.7	16.7	13.4	16.3	13.9	16.4	13.5	16.3	13.7	16.7	13.4	16.5	-	16.3	-	16.3

Since individual data on 'bent-arm hang' and 'leg lift test' for 12 year olds were not available, median scores could not be calculated.

Since individual scores on 'bent-arm hang' and 'leg lift test' for 12 year olds in 1980 were not available we could not statistically test differences between 1980 and 2006 for this age category. Median scores on 'bent-arm hang' and 'leg lift test' are presented in table 4 and show a decrease on 'bent-arm hang' and an increase in 'leg lift test' in all categories.

Discussion

The aim of this study was to compare the neuromotor performance on MOPER fitness test of Dutch children aged 9–12 with same aged children over a 26-year period (1980–2006). Because the MOPER fitness test includes more items of neuromotor fitness than just power and speed tests, this study gives a rather complete insight into the changes in neuromotor fitness in present youth. Compared to 1980, neuromotor performance on MOPER fitness test items in 2006 was significantly worse on almost all test items for boys and girls of all ages. This finding is of importance because children with poorer motor skills may become less active adolescents with associated poorer fitness levels[16]. Children who are proficient at performing motor skills may participate more in the type of activities likely to increase fitness levels. Scores on MOPER fitness test items in 2006 are within the range of test items scores found in other studies[4,8,11]. The prevalence of overweight and obesity among the study population in 2006 are comparable to the results from a national study on the prevalence of overweight and obesity among a representative selection of Dutch youth during 2002–2004[26]. Besides differences in performance on MOPER fitness test items between 1980 and 2006, the present study also indicates that today's youth are significantly taller and heavier. Because individual data of body height and body weight were not available from the study of Leyten [20], no statistical comparison of individual BMI between study populations in 1980 and 2006 could be made. However the estimated mean values suggest the same trend. International studies suggest a negative association between BMI and performance on neuromotor fitness tests[1,8,13]. This corresponds with our findings. For boys and girls in the 2006 data, higher BMI was correlated with lower performance on 'bent-arm hang', 10×5m run', 'leg lift test', 'vertical high jump' and 'arm pull adjusted' ($r = 0.19–0.45$). There was no association between BMI and performance on 'plate tapping' and 'sit and reach' ($r = 0.00–0.03$). An increase in BMI may both reflect an increase in fat mass as well as in fat-free mass[13,27]. An increase in fat mass has a negative effect on fitness measures that require moving, lifting and supporting of the body against gravity[13,14,28].
However, an increase in fat-free mass should enhance performance on power and strength measures[13,14] . When all overweight and obese children in the present study were excluded from the analysis, almost all differences in performance on MOPER fitness test items between 1980 and 2006 remained significant. This finding suggests that increased BMI cannot fully explain the inferior performance in 2006.
Tomkinson[13] reported a downward trend in neuromotor fitness of children worldwide since the 1980's. Changes in neuromotor fitness were calculated using performance on

power and speed tests. On speed test performance, Tomkinson[13] reported a decline of 0.08–0.09% per annum for children in the 1980's and 1990's. Results from the present study (mean decline of 0.13% per annum on '10×5m run') showed that changes in speed tests performance in Dutch youth are greater than those documented by Tomkinson[13] . A possible explanation for this difference might be that Tomkinson[13] combined performance on sprint running tests and agility sprint running tests to calculate speed performance. Sprint running tests only administer speed, while agility sprint running tests administer both speed and agility. If performance on both speed and agility has decreased through the years, decrease of performance on agility sprint running tests (as in '10×5m run' in the present study) will be greater than on sprint running alone. Tomkinson's [13] calculated performances on power tests, included performance on vertical high jump tests. Contrary to his results from – i.e. a decline of 0.01–.029% per annum– differences in 'standing high jump' in our study showed a mean increase in performance of 0.57% per annum. Apparently, differences in Dutch youth in this test of performance over the period 1980–2006 are not comparable with the secular changes documented by Tomkinson [13] . Because our data only provide two snapshots of neuromotor fitness in Dutch youth in 1980 and 2006, research results of neuromotor performance in Dutch youth from the intermediary years should have provided a more complete picture of these changes. Data of our study in 2006 and data of the study of Leyten[20] are representative for the distribution of the Dutch population during the measurement period regarding the level of urbanisation of the residences of participating schools. However, the study population in 2006 included relatively more children living in an urban residence compared to the study population of Leyten (60% vs. 48% in 1980). Thus, difference may exist between the two populations regarding social status and ethnicity. Representation of children's performance on the MOPER fitness test was based on gender and age. State of maturation was not measured and hence not taken into account. The last decades the age of menarche has advanced by 3–4 months per 10 years and the age at which boys' voice break has advanced by 2 months[14]. Some studies suggest that the ranking of physical fitness measures by calendar age will lead to many children being incorrectly classified[29,30]. Since more mature children perform better than less mature ones, this suggests that children in 2006 should perform better than same aged children in 1980, based on state of maturation alone. In the present results, representation based on state of maturation would presumably lead to even greater differences in performance between 1980 and 2006, while the increase in performance on 'standing high jump' would diminish.

Conclusion

Current results suggest that present 9–12-year-old Dutch youth are physically not as fit as same aged children were in 1980. Although BMI increased, this did not account for most differences in neuromotor fitness between 1980 and 2006 in 9–12-year-old Dutch youth. As the majority of physical activities of children involve high-intensity bursts such as jumping and sprinting, this decrease in neuromotor fitness may negatively affect children in their daily physical activity levels and in the long term their health status[13,14].

Practical implications

- This observed decrease in neuromotor fitness of present Dutch youth, may negatively affect their daily physical activity levels and in the long term their health status.
- To prevent poor fitness levels of present Dutch youth, an active lifestyle during childhood should be encouraged to obtain good physical fitness during childhood and adolescence.
- To prevent further declines in fitness levels regular screening and treatment of inadequate neuromotor fitness in youth is recommended.

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