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Development of motor talents and nontalents in preschool age – An exploratory study

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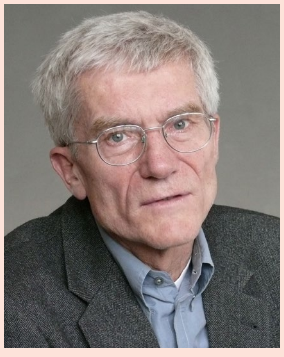
Abstract: Using a 21-month longitudinal design, the development of physical characteristics (height, body weight, BMI, skinfold thickness), of physical skills (coordination, fitness, manual dexterity), and cognitive performance (concentration, verbal ability, intelligence) was investigated in 568 children aged 37–78 months. According to their performance in a Motor Test Battery, children were classified at the beginning of the study as high performing (percentile rank > 90 %), average performing (rank > 40 and <60), or underperforming (rank <10 %). Twenty-four children of the high, 54 children of the average, and 27 children of the underperforming groups took part at each of three trials (start, 10, and 21 months later). All groups improved their motor performance over trials. Children with high motor performance at the beginning of the study did perform better in coordination, fitness, and manual dexterity compared to average or low performing children at each trial. And they outperformed children with lower motor skills in concentration at each trial and in intelligence at the end of the study. Underperforming children had higher indices of body weight at each trial compared to high performing children and their health status was considered as less favorable; however, groups did not differ in standing height.

Subjects: Sports Psychology; Talent Identification; Developmental Psychology; Gifted & Talented

Keywords: motor development; talent; preschool age; cognitive abilities; longitudinal study



Heinz Krombholz

ABOUT THE AUTHOR

Heinz Krombholz is currently affiliated to the State Institute of Early Childhood Research in Munich (IFP), Germany. He studied psychology and sports science, received his doctorate (PhD) from the Free University Berlin in 1987, and has worked as a research scientist and lecturer in German universities. His research interests include the development of motor abilities and the promotion of motor skills in children and aspects of health and laterality. He is especially interested in the development of motor-talented children and of children with developmental coordination disorders. Heinz Krombholz has published about 100 contributions and scientific articles in books and peer-reviewed journals.

PUBLIC INTEREST STATEMENT

Sport is a multi-billion dollar business and the identification of talents is of enormous importance. Although little is known about the development and promotion of motor skills in preschool age, there are efforts to start talent scouting and training in sports such as soccer, gymnastics, tennis, and skating even in four-year olds and sports competition often begins as early as age 6. The study investigated the development of motor-talented compared to nontalented preschoolers. The talents kept their high position compared to nontalented children for two years not only in coordination, fitness, and manual dexterity, but also in cognitive performance. These findings support the concept of "general talent" compared to "domain-specific talent". There was also a clear association between skill status and body composition: children of the low performing group were heavier and had greater skinfolds and BMIs compared to talented children.

1. Introduction

Individuals who have a predisposition for or already show high performance in a particular area are referred as gifted or talented (Moon, 2003) and athletic talent means an exceptional natural ability of an individual to perform a sports-related task or ability (Gray & Plucker, 2010, p. 362). In his model of giftedness and talent, Gagné (2003, 2008) defines each person from a percentile rank of 90 as "gifted" or "talented", but there are also more stringent criteria recommended (Hohmann & Carl, 2002). In most cases, the term "gifted learners" is used with cognitive performances, the term "talented learners" with musical, creative, or sporting achievements. Identification of gifted or talented individuals and programs to develop the performance of those individuals has gained popularity in recent decades and there is an intense and controversial debate about this phenomenon in psychology, sports psychology, sports science, sports education, and also in the general public (cf. Cobley, Schorer, & Baker, 2012; Heller, Mönks, & Sternberg, 2002; Howe, Davidson, & Sloboda, 1998; Simonton, 2001; Vaeyens, Lenoir, Williams & Phillippaerts, 2008; Williams & Reilly, 2000). However, there remains a lack of consensus about the definition or identification of the concept "gift" or "talent" and no accepted theoretical framework to guide current practice exists (Gagné, 2003, 2008).

Models of the phenomenon talent assume (a) continuity of development and (b) the dominance of genetic influences (Lite, 2008). Although the heritability index for maximum performance in sports is high ($h^2 = 0.85$), additional environmental factors and the interaction of nature and nurture are generally recognized (Vinkhuyzen, van der Sluis, Posthuma, & Boomsma, 2009). However, researchers proposed that individual differences in performance in such domains as music, sports, and games once believed to reflect innate talent are the result of intense training and of deliberate practice (10 years and 10,000 h) (Ericsson, Krampe, & Tesch-Römer, 1993). This view was a frequent topic of popular science writing, but Macnamara, Hambrick, and Oswald (2014) conducting a meta-analysis covering all major domains investigated concluded that deliberate practice is important, but not as important as has been argued; they found that deliberate practice explained only 18% of the variance in performance for sports.

It seems obvious that children and teenagers have to rely on the support from their environment and intensive learning and training phases are essential for achieving excellence, even under optimal talent potential. This applies equally to artistic performances such as music, visual arts, dance, and literature, cognitive performance such as mathematics and foreign language learning, games like chess, and not at least for peak performance in sports (Cobley et al., 2012; Côté, 1999; Vinkhuyzen et al., 2009). Although significant correlations were found in individuals with a "normal" performance level between preschool age, school age, and adulthood (Ahnert & Schneider, 2007), a forecast for top level in sports over a longer period is hardly possible since obviously complex endogenous and exogenous conditions are important for athletic performance (Abbott & Collins, 2004; Elferink-Gemser, Jordet, Coelho-E-Silva, & Visscher, 2011).

The growth and the maturity status of children of the same age can be rather different (Manna, 2014) and the role of physical maturity in childhood as an advantage in being viewed as sport talent, e.g. in soccer, ice hockey, or basketball, is widely recognized, at least in boys (the relative age effect, Brewer, Balsom, & Davis, 1995; Dudink, 1994; Edwards, 1994; Steingröver, Wattie, Baker, & Schorer, 2016; Ulbricht, Fernandez-Fernandez, Mendez-Villanueva, & Ferrauti, 2015). Sex differences in motor performance can be found already in preschool age, boys exceed in speed and power-related tasks, girls in coordination and dexterity (Krombholz, 2006; Thomas & French, 1985). Boys and girls who attended physical education lessons in sport clubs performed better on motor skills and more children of higher socioeconomic status attended sport clubs in preschool age (Krombholz, 2006). The association between different motor skills and between motor performance and cognitive abilities was significant (Burrman & Stucke, 2009; Krombholz, 2006). Malina (2004) stated that firstborn infants receive more stimulation by parents and generally show advanced motor behavior compared to later born.

Although little is known about the development and promotion of motor skills in preschool age and it is questionable whether the construct "talent" is appropriate and talents can be reliably detected already in this age (Hohmann & Seidel, 2003), there are efforts to start talent scouting and training in sports such as skating, tennis, and soccer even in four-year olds (Elferink-Gemser, 2013).

Investigating the development of motor performance in groups of different performance levels has both theoretical and practical significance for Developmental Psychology and Sports Science (Heller et al., 2002; Krombholz, 1998; Malina, 2004). How do motor skills change in childhood, continuously or discontinuously? How stable are different motor abilities during certain developmental periods? What about the course of development of different motor skills? Which external factors can promote the development of motor skills? Answers to these questions have significance for formulating theoretical concepts and models of human motor skills (Krombholz, 1998). It is of practical relevance to the selection and promotion to investigate the development of children considered sport talents. Do they keep their high level without any further support, are there factors that promote or hinder their development (see Hohmann & Seidel, 2003)? In children with low motor performance or motor deficits (e.g. children with developmental coordination disorders DCD), it is of special interest whether their motor performance improves or deteriorates without intervention (Krombholz, 2005b).

The present literature on talent deals with two questions in particular (see Howe et al., 1998; Macnamara et al., 2014; Vinkhuyzen et al., 2009): (a) The role of heredity, environment, and training (nature vs. nurture) in achieving excellence. (b) Does talent include a wide range of skills ("general aptitude") or is talent specific to a certain kind of performance ("special talent"/"specific talent")? Longitudinal studies on sport or skill talents or nontalents in early childhood have not been conducted. The current study therefore investigated the development of physical characteristics and of motor and cognitive performance of children with low, average, and high motor skills in preschool age. Due to present findings, significant improvements in motor and cognitive performance over a period of 21 months were expected. And it was assumed that compared to less talented children motor talented children:

(1) maintain their high status during the study,
(2) show an advantage in their physical development,
(3) are also superior in cognitive performance,
(4) grow up in more privileged backgrounds and
(5) a higher percentage of them are firstborn children.

2. Method

2.1. Participants

Participants were children attending childcare centers in the city of Munich, Germany. The study was accepted by the Scientific Advisory Council of the State Institute of Early Childhood Research, Munich. All parents agreed to their children participating in the study. Data were available for 568 children (288 boys and 280 girls) aged 37 to 78 months (M = 58.4, SD = 9.6).

2.2. Measures

Dependent variables were aspects of physical growth, body composition, and motor and cognitive performance (cf. Table 1).

2.2.1. Anthropometric measures

Anthropometric measures were height, weight, BMI (= weight (kg)/(height (m))^2), and skinfold thickness (mean of three sites: abdomen, scapula, triceps).

Table 1. Dependent variables at each of three trials

Anthropometric data
Age (months)
Sex
Height (cm)
Skinfold thickness (mean on 3 sites: abdomen, scapula, triceps) (mm)
Body mass index BMI = weight (kg)/height (m^2)
Motor skills
Motor Test Battery MoTB 3–7, Krombholz, 2011 (*z*-score) assess three aspects:
Body coordination (z-score)
Balancing forward (number, max. 24)
Balancing backward BR and Lateral jump LJ (Body Coordination Test BCT, Kiphard & Schilling, 2007; number)
Hopping, right and left foot (number, max. 20)
Fitness (z-score)
Standing broad jump (cm)
Hanging task (s, max. 30)
Shuttle run: distance: 4 × 4 m (s)
Dexterity (z-score)
Right and left hand, Performance of the dominant hand (Lateral Dominance Test—LDT, Schilling, 2009) (number)
Cognitive Abilities
Concentration
Frankfurter Tests für Fünfjährige—Konzentration FTF-K, Raatz and Möhling (1971) (number)
Verbal ability
Peabody picture vocabulary test PPVT, Dunn (1959), German version: Bondy et al. (1975) (number)
Intelligence
Culture Fair Test 1 CFT 1, Weiß & Osterland, 1997 (this test was only applied at the third trial) (*T*-score)

2.2.2. Motor performance

Motor performance was measured by a Motor Test Battery (MoTB 3–7, Krombholz, 2011). This test battery is an instrument with sufficient reliability (Cronbach's Alpha = 0.88, retest reliability for total score after 8 months: $r = 0.79$) to measure motor abilities in a valid way (face and construct validities, Krombholz, 2011).

The motor test battery consists of tasks that assess three dimensions of motor performance: *motor coordination* (5 items), *physical fitness* (3 items), and *manual dexterity* (2 items). *Motor coordination* was measured by five tests. Forward balancing consisted of walking over beams that were 3, 4.5, and 6 cm wide. There was one trial on each beam, starting with the 6-cm beam. The number of steps without leaving each beam was recorded; the maximum number for each trial was 8, yielding a maximum score of 24. Hopping on the right and left feet was performed, starting with the preferred foot, and performing two trials with each foot. The number of correct hops for each trial was counted; the maximum number was 20 and the dependent variable was the mean of two trials. Backward balancing, an item of the Body Coordination Test KTK (Kiphard & Schilling, 2007),[1] consisted of walking backward on three balance beams that were 3, 4.5, and 6 cm wide. Children were instructed to walk slowly backward on the balance beams, starting with the 6-cm beam. There were three trials for each beam; the number of steps without leaving each beam was recorded; the maximum number for each trial was 8, yielding a maximum score of 72. Also, lateral jump, an item of the KTK (Kiphard & Schilling, 2007), was given. This task consisted of jumping to the left and right over a dividing line as quickly as possible for a total time of 15 s, taking off and landing on both feet simultaneously. There were two trials and the total number of jumps was taken as the dependent variable.

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Physical fitness measures included three items evaluating explosive leg power and coordination (standing broad jump), running speed and agility (shuttle run), and muscular endurance or functional strength (hanging). In the standing broad jump, children stood with their toes at the starting line, with their feet comfortably apart, and then jumped as far as possible (cm). The maximum of two trials was used as the dependent variable. For the shuttle run, there was a distance of 4 m marked by two squares (30 × 30 cm). The child started in one of these squares. In the other square there were two small wooden blocks. The child had to fetch these blocks, one after the other, and put them in his square. The best of two trials was used as the dependent variable (time in s). In the hanging task, children had to cling as long as possible to a horizontal bar of 2.5 cm diameter, feet not supported, arms stretched. Time was measured in seconds with a maximum of 30 s allowed. The mean of two trials was used as the dependent variable.

Manual dexterity in both the right and the left hands was measured by a paper-and-pencil test (Lateral Dominance Test LDT, Schilling, 2009). This test requires participants to touch small circles 2 mm in diameter, with a special pen. For each hand there were 150 circles; the number of circles touched correctly was the score.

2.3. Cognitive abilities

Cognitive abilities tested included intelligence (Culture Fair Test 1; Weiß & Osterland, 1997), verbal ability (Peabody Picture Vocabulary Test; Dunn, 1959; German version: Bondy, Cohen, Eggert, & Lüer, 1975), and concentration (Frankfurter Test für Fünfjährige – Konzentration; Raatz & Möhling, 1971).

2.4. Family circumstances and other abilities

In addition, information about the children's abilities and family circumstances was assessed by a questionnaire for parents, e.g. ability to ride a bicycle or to swim, health status (very good, good, satisfactory, or sufficient), sports activities of children in sports clubs or facilities to play at home and in the neighborhood. Socioeconomic status was estimated by self-classification based on the occupation of parents (Lower: skilled or unskilled manual; Middle: lower grade professionals, administrators; Upper: higher grade professionals, administrators)[2]. Immigration status was determined by the child's mother tongue (German or non-German).

2.5. Procedure

Data were collected in childcare centers. Anthropometric data were recorded by medical staff of the city of Munich. Measuring methods corresponded to standard measuring procedures using a portable stadiometer (Dr. Keller III, Günther GmbH, Tauscha, Germany), portable scales (FG-150K-EC, A & D Instruments, Abingdon, England), and skinfold caliper (GPM SC, SiberHegner & Co., Zürich, Switzerland) with children in underwear and no shoes.

Motor tests were conducted in groups of five children and were demonstrated by test instructors. Fine motor and cognitive tests were administered individually. Testing was done by specially trained test administrators. For further details of the items measured and procedures see Krombholz (2005a, 2011).

2.6. Analyses

Data were analyzed using SPSS version 21. Significance level for all tests was $p < 0.05$. The associations between motor skill status (low, medium, high) and sex, social status, immigration status, and other categorical variables were analyzed by means of χ^2-tests; the effect sizes are reported as Cramer's *V*. Differences between groups for each dependent variable were tested by analyses of variance (ANOVAs) with *post hoc* tests (Bonferroni). The course of development for motor performance (MoTB 3–7, total, coordination, fitness, manual dexterity) and cognitive abilities (verbal ability, concentration) was analyzed using ANOVAs for repeated measures. Multivariate analysis of variance (MANOVA) for repeated measures was calculated for physical characteristics (height, weight, BMI, skinfold thickness). If multivariate effects were significant, univariate analyses were carried through for each dependent variable. To estimate effect sizes, partial eta squared (η^2_p) values were calculated.

3. Results

Children were tested three times, when they entered child care centers and again after 10 and 21 months. In accordance with the criteria of Gagné (2003, 2008) children were classified at the start of the study ($N = 568$) as low (percentile rank PR < 10, $N = 56$), medium (PR > 40 and < 60, $N = 113$), or high performing (PR > 90, $N = 54$) in motor skills according to their performance in the MoTB 3–7. However, since not all children could be tested at all trials, only 105 children took part in all follow-ups (age range: 37 to 68 months, low skill status: $N = 27$, medium status: $N = 54$, high status: $N = 24$, cf. Table 2). About half of the children did not finish the second or third trial. However, the loss was due to chance: the percentage of drop outs was nearly the same for the tree status groups (low: 51%, medium: 52% high: 56%, χ^2-test not significant) and there were no differences for age, physical characteristics, motor performance, verbal ability, and concentration at the first trial between children who finished all trials and children who left the cohort (ANOVAs).

Although there is a tendency that boys are more strongly represented in both the upper and the lower performing groups, χ^2-analyses revealed no association between skill status and sex (χ^2 (2) = 4.2, $p = 0.124$, Cramer's $V = 0.137$). No connection was found between skill status and social status (χ^2(2) = 3.1, $p = 0.217$, Cramer's $V = 0.150$), but with migration status: a higher percentage of children in the low skill group had an immigrant background compared to the high skill group (χ^2 (2) = 9.7, $p = 0.010$, Cramer's $V = 0.264$). More children of the high than of the low skill group attended regularly or occasionally practice sessions of sports clubs (45 vs. 7%, χ^2(2) = 26.1, $p = 0.001$, Cramer's $V = 0.433$), and parents rated their health higher (χ^2 (2) = 10.2, $p = 0.036$, Cramer's $V = 0.190$). A higher percentage of children classified as high performing were able to swim and ride a bicycle (44 vs. 28% and 93 vs. 7%), but the difference was only statistically significant in cycling (χ^2 (2) = 20.3, $p = 0.001$, Cramer's $V = 0.380$). Among the less talented children there were more first-born children than among the high talented (50 vs. 29%, χ^2(2) = 7.3, $p = 0.001$, Cramer's $V = 0.229$). Correlations for motor skills were high between the first and the last trials (all children: $r = 0.82$, $p < 0.001$, low status: $r = 0.42$, $p = 0.046$, medium status: $r = 0.43$, $p < 0.001$, high status: $r = 0.79$, $p < 0.001$).

Table 3 shows the means and standard deviations for dependent variables for children classified as low, medium, and high performing in motor skills on the three trials. Results of statistical tests are also given (ANOVAs: p, effect size: partial eta squared (η^2), *post hoc* tests: p).

Anthropometric parameters: Skill groups did not differ in age and there were no differences in standing height between skill groups, but in parameters associated with weight. Children belonging to the low status group were heavier and had greater skinfolds and BMIs compared to the children of the high status group at each trial.

Motor skills: Significant differences between groups could be found in motor skills (total score and coordination, fitness, and manual dexterity) at each trial, effect sizes were high or at least medium. Differences between low, medium, and high groups were significant: Not only in the beginning, the

Table 2. Status of motor performance (low, medium, high) and sex, number, and percentage at the start of the study

	Low		Medium		High		Total	
	N	**%**	***N***	**%**	***N***	**%**	***N***	**%**
Boys	19	18.1	24	22.9	14	13.3	57	54.3
Girls	8	7.8	30	28.6	10	9.5	48	45.7
Total	27	25.7	54	51.4	24	22.9	105	100

Table 3. Development of aspects of physical growth, motor skills, and cognitive abilities in children with low, medium, or high motor performance status at three trials

	Low		Medium		High		ANOVA		Post-Hoc (p)		
							p	η^2	l/h	l/m	m/h
1st Trial	M	SD	M	SD	M	SD					
Age (Month)	58.1	9.6	58.5	9.9	59.2	9.3	0.84	<0.01	ns	ns	ns
Height (cm)	108.4	5.9	108.8	5.3	107.9	6.3	0.528	<0.01	ns	ns	ns
Weight (kg)	19.3	3.2	18.9	2.6	17.9	2.4	0.005	0.05	0.01	ns	ns
Skinfold (mm)	5.6	2.3	4.7	1.4	4	1	<0.001	0.13	0.01	0.01	0.05
BMI	16.3	1.8	15.3	1.3	15.3	1	0.001	0.07	0.01	.ns	0.04
MoTB 3–7 Total	−1.17	0.44	−0.15	0.41	0.75	0.47	<0.001	0.61	<0.01	<0.01	<0.01
MoTB 3–7 Coord	−1.11	0.36	−0.15	0.5	0.85	0.51	<0.001	0.58	<0.01	<0.01	<0.01
MoTB 3–7 Fitness	−1.06	0.77	−0.14	0.53	0.59	0.38	<0.001	0.47	<0.01	<0.01	<0.01
MoTB 3–7 Dex	−0.70	0.4	−0.13	0.58	−0.03	0.71	<0.001	0.14	<0.01	<0.01	<0.01
Cognitive abilities											
Conc (Num.)	17.2	4.5	20.2	7.8	22.4	7.3	0.011	0.04	0.01	0.05	ns
Verb. Ab (num.)	28.2	18.9	36.6	18	37.2	16.8	0.004	0.05	0.07	<0.01	ns
2nd Trial											
Height (cm)	113.6	6.2	113.9	5.5	113.1	6.5	0.396	0.01	ns	ns	ns
Weight (kg)	21.9	4.1	20.8	4.1	20	2.6	0.007	0.06	0.01	ns	ns
Skinfold (mm)	6.8	4	4.9	1.9	4	1.1	<0.001	0.14	<0.01	<0.01	ns
BMI	16.9	2.2	15.9	1.4	15.6	0.9	0.002	0.08	0.01	0.02	ns
MoTB 3–7 Total	−1.09	0.62	0.03	0.46	0.77	0.52	<0.001	0.56	<0.01	<0.01	<0.01
MoTB 3–7 Coord	−1.18	0.55	0.03	0.52	0.79	53	<0.001	0.57	<0.01	<0.01	0.01
MoTB 3–7 Fitness	−0.95	0.84	−0.08	0.67	0.61	0.63	<0.001	0.34	<0.01	<0.01	<0.01
MoTB 3–7 Dex	−0.58	0.61	0.01	0.8	−0.09	0.81	<0.001	0.12	<0.01	<0.01	ns
Cognitive abilities											
Conc (num.)	20.5	7.3	25.9	7.3	26.7	7.7	<0.001	0.13	<0.01	<0.01	ns
Verb.Ab (num.)	40.7	16.7	44.8	15.5	45.7	14.4	0.043	0.04	0.05	.ns	ns
3rd Trial											
Height (cm)	118.8	6.6	118.3	5.6	117.3	6.7	0.708	0.01	ns	ns	ns
Weight (kg)	24.1	4.9	22.5	4	21.4	3	0.016	0.06	0.01	ns	ns
Skinfold (mm)	8.3	4.6	5.9	3.1	4.6	1.2	<0.001	0.16	<0.01	<0.01	ns
BMI	17	2.4	15.9	1.7	15.5	1.1	0.002	0.09	<0.01	0.01	ns
MoTB 3–7 Total	−0.93	0.69	0.16	0.49	0.91	0.54	<0.001	0.58	<0.01	<0.01	<0.01
MoTB 3–7 Coord	−1.01	0.67	0.23	0.46	0.84	0.48	<0.001	0.61	<0.01	<0.01	0.01
MoTB 3–7 Fitness	−0.63	0.79	0.04	0.64	0.74	0.55	<0.001	0.34	<0.01	<0.01	<0.01
MoTB 3–7 Dex	−0.47	0.5	−0.01	0.72	0.77	0.84	<0.001	0.26	<0.01	<0.01	<0.01
Cognitive abilities											
Conc (num.)	23.5	7.7	28.4	8.7	31.3	7.6	<0.001	0.12	<0.01	0.05	ns
Verb. Ab (num.)	50.1	13.9	55.2	8.7	56.3	7.3	0.021	0.06	0.1	0.02	ns
Intellig (T-score).	49.9	7.7	54.3	7.5	56.5	7.5	0.023	0.04	<0.01	<0.01	ns

Notes: Means *M*, Standard Deviations SD, Results of ANOVAs, *p* and partial η^2, and of Post hoc Tests (Bonferroni), *p*.

Abbreviations: low or *l* = low skill status, medium or *m* = medium skill status, high or h = high skill status, MoTB 3–7 = motor test battery 3–7, coord = coordination, dex = dexterity, verb.*ab* = verbal ability, conc = concentration, intellig = intelligence, ns = not significant.

high group surpassed the medium and the low groups and the medium group surpassed the low group.

Cognitive abilities: There were no significant differences between the high and the medium skill groups in cognitive abilities. However, the high and the medium groups outperformed the low group in concentration at each trial and in intelligence at the third trial, and the medium group outperformed the low group at the first and the second trials in verbal abilities.

3.1. Development over trials

The connection between skills group and trial and aspects of physical growth (height, weight, BMI, and skinfolds) was investigated by an analysis of multivariate variance for repeated measurements (MANOVA). Results are given in Table 4. As expected, there was a significant gain in height, weight, BMI, and skinfold thickness ($p < 0.001$, $\eta^2 = 0.98$); however, the interaction between skills group and trial was also significant ($p = 0.003$, $\eta^2 = 0.16$): low performing children showed greater increase in weight, skinfolds, and BMI compared to children of medium or high skill status.

The development of motor performance of children classified as low, medium, or high performing in motor skills in the beginning of the study is illustrated in Figure 1, results of statistical analysis (ANOVA) are presented in Table 5, the factor sex was included in this analysis. Skill groups differed in motor performance ($p < 0.001$, $\eta^2 = 0.72$) and there was an increase in motor performance over trials ($p < 0.001$, $\eta^2 = 0.22$). The performance of boys and girls did not differ and none of the interactions was significant.

Results for analyses of the development of the three dimensions of motor skills assessed by the MoTB 3–7—coordination, fitness, and manual dexterity—are given in Tables 6–8. The results agreed with those for total score concerning the effects of skill status and trial. The differences between skill groups were significant (*post hoc* tests: $p < 0.001$). However, boys outperformed girls in fitness ($p = 0.003$, $\eta^2 = 0.07$) and girls outperformed boys in manual dexterity ($p < 0.001$, $\eta^2 = 0.13$). The interaction between skill status and trial was significant both for coordination ($p = 0.012$, $\eta^2 = 0.05$) and manual dexterity ($p = 0.003$, $\eta^2 = 0.07$). The medium skill group showed greater gains in coordination than the low and high skill groups and the high skill group showed greater gains in dexterity than the medium and low skill groups.

Results for analyses (ANOVAs) of the development of cognitive abilities (concentration and verbal ability) are presented in Tables 9 and 10. The effects of trial and skill status were significant for both concentration and verbal ability, effect sizes were high ($p < 0.004$, $\eta^2 > 0.09$). Post hoc tests revealed differences between high and medium vs. low status groups in concentration ($p = 0.001$) and between high vs. medium and low groups in verbal abilities ($p = 0.049$). Children belonging to the high skill group outperformed children belonging to the low skill group. The effects sex and sex x trial were significant for verbal ability: boys outperformed girls, $p < 0.001$, $\eta^2 = 0.11$) and girls showed greater gains than boys ($p = 0.004$, $\eta^2 = 0.07$).

Table 4. MANOVA of physical growth (height, weight, skinfolds, BMI)

Effect	*F*	*df*	*p*	η^2
Performance Status	2.3	8; 98	0.02	0.09
Trial	666	8; 98	<0.001	0.98
Performance Status * Trial	2.4	16; 194	0.003	0.16

Note: Effects: Motor performance status (low, medium, high) and trial.

Figure 1. Development of motor performance (MoTB 3–6, *z*-scores) of children with different motor skill status.

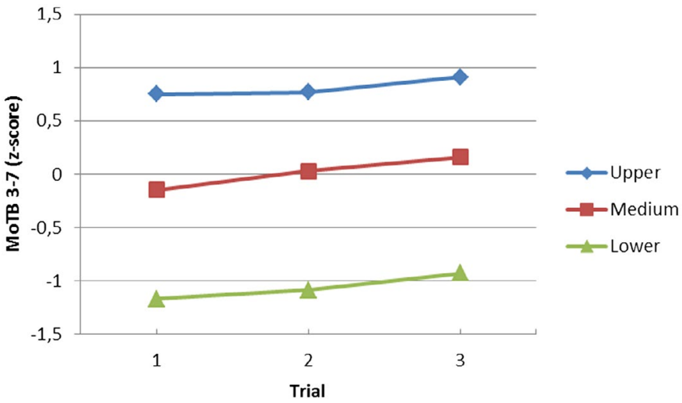

Table 5. ANOVA of motor skills (MoTB 3–7, *z*-score)

Effect	*F*	*df*	*p*	η^2
Performance status	126.8	2; 99	<0.001	0.72
Sex	0.1	1; 99	0.724	<0.01
Performance status * Sex	1.8	2; 99	0.169	0.04
Trial	13.8	2; 98	<0.001	0.22
Performance status * Trial	0.7	4; 194	0.61	0.01
Sex * Trial	0.3	2; 98	0.748	0.01
Perform status * Sex * Trial	0.9	4; 194	0.489	0.02

Note: Effects: Motor performance status (low, medium, high), sex, and trial.

Table 6. ANOVA of motor skills (MoTB 3–7, coordination: balancing forward and backward, lateral jump, hopping, *z*-score)

Effect	*F*	*df*	*p*	η^2
Performance status	146.0	2; 118	<0.001	0.71
Sex	0.1	1; 118	0.779	<0.01
Performance status * Sex	1.3	2; 118	0.283	0.02
Trial	11.8	2; 117	<0.001	0.27
Performance status * Trial	3.3	4; 232	0.012	0.05
Sex * Trial	0.5	2; 117	0.632	0.01
Perform status * Sex * Trial	0.3	4; 232	0.902	0.01

Note: Effects: Motor performance status (low, medium, high), sex and trial.

Table 7. ANOVA of motor performance (MoTB 3–7, fitness: standing broad jump, 20 m dash, holding, *z*-score)

Effect	*F*	*df*	*p*	η^2
Performance Status	63.3	2; 119	<0.001	0.52
Sex	9.5	1; 119	0.003	0.07
Performance Status * Sex	0.7	2; 119	0.483	0.01
Trial	9.9	2; 118	<0.001	0.14
Performance Status * Trial	1.2	4; 234	0.305	0.02
Sex * Trial	1.2	2; 118	0.295	0.02
Perform Status * Sex * Trial	1.4	4; 234	0.237	0.04

Note: Effects: Motor performance status (low, medium, high), sex and trial.

Table 8. ANOVA of motor performance (MoTB 3–7, manual dexterity: right/left hand, *z*-score)

Effect	*F*	*df*	*p*	η^2
Performance status	21.3	2; 111	<0.001	0.27
Sex	17.0	1; 111	<0.001	0.13
Performance status * Sex	0.7	2; 111	0.535	0.01
Trial	10.3	2; 110	<0.001	0.16
Performance status * Trial	4.1	4; 218	0.003	0.07
Sex * Trial	2.1	2; 110	0.123	0.04
Perform Status * Sex * Trial	1.2	4; 218	0.321	0.04

Note: Effects: Motor performance status (low, medium, high), sex and trial.

Table 9. ANOVA of concentration (raw-scores)

Effect	*F*	*df*	*p*	η^2
Performance status	8.4	2; 112	<0.001	0.13
Sex	0.1	2; 112	0.921	0.01
Performance status * Sex	1.8	2; 112	0.169	0.03
Trial	67.3	1; 112	<0.001	0.38
Performance status * Trial	0.9	2; 112	0.411	0.02
Sex * Trial	0.7	1; 112	0.402	0.01
Perform status * Sex * Trial	0.2	2; 112	0.857	0.01

Note: Effects: Motor performance status (low, medium, high), sex, and trial.

Table 10. ANOVA of verbal ability (raw-scores)

Effect	*F*	*df*	*p*	η^2
Performance status	5.8	2; 112	0.004	0.09
Sex	14.3	2; 112	<0.001	0.11
Performance status * Sex	1.6	2; 112	0.199	0.03
Trial	214.9	1; 112	<0.001	0.66
Performance status * Trial	1.8	2; 112	0.167	0.03
Sex * Trial	8.8	1; 112	0.004	0.07
Perform Status * Sex * Trial	1.7	2; 112	0.205	0.03

Note: Effects: Motor performance status (low, medium, high), sex, and trial.

4. Discussion

The present study investigated the development of motor performance in children with different skill levels in preschool age. Based on their performance in a motor test battery (MoTB 3–7, Krombholz, 2011) at the beginning of the study, three groups were distinguished: children with low (percentile rank < 10), average, and high performance (percentile rank < 90). The upper group comprised children who can be considered as "sport talents" in accordance with the criteria/definition of Gagné (2003, 2008). However, there is a controversy whether the construct "talent" is appropriate and talents can be reliably detected already at this age (Hohmann & Seidel, 2003). In the low performing group, children's performance was not appropriate for their age, and 11 (41%) showed symptoms of Developmental Coordination Disorders DCD.

Although there were more boys than girls in both the upper and the lower skill groups, the association between skill status and sex was not statistically significant. The hypothesis that the high skill children grow up in more privileged backgrounds could not be confirmed, no connection was found between skill status and social status. However, a higher percentage of children of the low skill group had an immigrant background compared to the high skill group ($p = 0.010$). As expected, parents of the high skill children seem to support their physical development and more children of the high than of the low skill group attended practice sessions of sports clubs (45 vs. 7%), were able to swim and ride a bicycle (44 vs. 28% and 93 vs. 7%), and their health was considered as better by parents compared to the low skill group ($p = 0.036$). In contrast to the hypothesis that firstborn children show advanced motor behavior (Malina, 2004), there were more firstborn children among the less talented children than among the high talented (50 vs. 29%)—an older sibling may be a positive role model or parents are less restrictive with their second-born children engaging in physical activities (Krombholz, 2006). Accordingly, it is not clear whether talented children are willing or/and stimulated by their parents to attend practice sessions of sport clubs or whether attending sport clubs promotes physical performance. Both may be true.

The growth and the maturity status of children of the same age can be rather different (Manna, 2014) and the physical maturity in childhood is an advantage in being viewed as sport talent (Brewer et al., 1995; Dudink, 1994; Edwards, 1994; Steingröver et al., 2016; Ulbricht et al., 2015). However, there was no indication of a difference in the degree of physical maturity between high and low skill children and no differences in age and standing height between skill groups were found. But differences existed in parameters associated with weight: children belonging to the low skill group were heavier and had greater skinfolds and BMIs compared to the children of the high skill group at each trial. That connection intensified with age and corresponds to the results that overweight is associated with low physical performance in children (Castetbon & Andreyeva, 2012; Krombholz, 2012, Slining, Adair, Goldman, Borja, & Bentley, 2010).

As expected, significant differences between groups could be found in motor skills (total score and body coordination, fitness, and manual dexterity) at each trial, effect sizes were high or at least medium. Differences between low, medium, and high skill groups were significant: not only in the beginning, the high group surpassed the medium and the low groups and the medium group surpassed the low group. The delay of the lower skill group compared to the average skill group and the average compared to the high skill group corresponded to about the equivalent of two years of skill level. Sex differences could be found in fitness and manual dexterity: boys outperformed in fitness and girls in dexterity; this is not surprising (Krombholz, 2006; Thomas & French, 1985).

During preschool age, there are great gains in motor and cognitive skills due to maturing and learning processes (Krombholz, 1998; Manna, 2014; Thelen, 1995). Consequently, the tested motor and cognitive skills increased significantly over trials (effect sizes were high). Correlations for motor skills were significant between the first and the last trials for all children ($r = 0.82$), but higher for the high skill group ($r = 0.79$) compared to the medium ($r = 0.43$) and the low groups ($r = 0.42$). Between the ages of 46 to 65 months, the correlation for the performance in the Motor Test Battery (MoTB 3–7) was high ($N = 320$, $r = 0.76$, Krombholz, 2011) and Ahnert and Schneider (2007) too found significant correlations for coordination and explosive strength between preschool age, school age, and adulthood (23 years).

The three groups maintained their status and the increase in total motor performance was equal for different skill groups: no interaction was found between skill level and trial. Similar results were found by Haga (2009) in children 9 to 10 years old. However, the medium skill group showed greater gains in coordination than the low and high skill groups and the high skill group showed greater gains in dexterity than the medium and the low skill groups.

As for motor performance, there was a strong and significant trend for cognitive performance and significant differences between skill groups, effect sizes were high. Post hoc tests revealed differences between high and medium vs. low skill groups in concentration and between high vs. medium and low groups in verbal ability. Children belonging to the high skill group outperformed children belonging to the low skill group in concentration, verbal ability, and intelligence. In verbal ability, boys outperformed girls, but girls showed greater gains than boys. These results on the association between motor and cognitive performance are similar to those of the existing studies (a summary can be found in Burrman & Stucke, 2009).

Given the small number of children who could be identified as "motor talented" and followed over a period of nearly two years, further studies with more cases and over a longer period are recommended to validate the results. It should be noted that if a criterion is based on the distribution of a special performance in a population, as Gagné's 10% criterion, the definition of talent depends on the size and quality of the sample relied upon. The sample size in our study was 568. But a larger sample would most likely include children with even higher skill levels.

Despite these limitations, the findings tend to favor the concept of a general talent than specific talent or nontalent and the importance of family or environment—at least for motor skills in preschool (cf. Côté, 1999; Howe et al., 1998). There may be an interaction between talent of children and the promotion of motor skills by parents: parents encourage talented children to engage in vigorous games and to join sports teams. Furthermore, talented children experiencing success in movement games and different motor skills will engage more in those activities and consequently gain more competence (Gray & Plucker, 2010). The opposite may be true for "nontalented" or overweight children: experiencing failures they avoid motor challenges and playing movement games with peers (Krombholz, 2005b). Since we cannot allow these children to lose the benefits of sports, this vicious circle should be broken by parents and teachers (Black & Hurley, 2016).

According to recent findings, talent should be considered as necessary but far from sufficient importance for excellence in sports, intellectual, or artistic areas, in addition an intensive training over a longer period is essential for top performance (Cobley et al., 2012; Côté, 1999). And motor or athletic talent is a culmination of physiological, psychological, and support factors (Gray & Plucker, 2010).

For further study of the phenomenon, talent in childhood, it is appropriate to distinguish between the identification and the development and fostering of talent (Abbott & Collins, 2004). Given the increasing interest of the professional sport industry and also the efforts to find genetic factors in childhood to identify and promote talents already at a very early age, ethical considerations in the talent research are becoming increasingly important (Guth & Roth, 2013).

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Notes
1. A description of the first edition of the Body Coordination Test can be found in Zaichkowsky, Zaichkowsk, and Martinek (1980) (p. 42 ff).
2. The classification based on predefined occupations is highly associated with income and educational status and is considered a good predictor of social status in Germany (Züll, 2015).

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