Title:

Does Current Behavior Predict the Course of Children's Physical Fitness?

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Abstract:

The secular trend of reduced physical fitness leads to increased health risks. The aim of the present paper is to analyze various current factors that affect health behavior with respect to the course of physical fitness over 2 years. A path analysis combined with a latent growth curve analysis was based on a study that was conducted between June 2008 and June 2010 with 145 primary German school children (52.1% male, average age at baseline 7.95 years ± 0.95). Physical fitness was tested with the German Motor Test 6-18. For the mean physical fitness and the course of physical fitness, direct and indirect influences were shown over three levels, including migration background on the first level and physical activity on the second level. Body mass index impacted the mean physical fitness but not the course of physical fitness. The influence of sedentary behavior on the mean physical fitness was diminished (compared to bivariate analysis) due to its common variance mainly with body mass index. Physical activity affected not only current physical fitness in children but also the course of physical fitness ($a_{intercept}$ = .28, P = .001; a_{slope} = .27, P = .21). Consequently, preventive measures should focus on early adoption and maintenance of physical activity.

Keywords: migration background, school achievement, physical activity, BMI, media

Introduction

There is a secular trend that has been concerning sport and medicine scientists within the last few years: physical fitness (PF) parameters of children and adolescents have been worsening. In a global literature review, Tomkinson & Olds (2007) detected improvements from the late 1950s until approximately 1970 but declines of increasing magnitude every decade thereafter until the end of the reviewed studies in 2003. This decline is mainly found for aerobic fitness and is very consistent across age, sex, and geographical groups. Miscellaneous factors have been associated with PF for different population groups. Weight status is one of the most regarded factors. While PF decreases, the body mass index (BMI) in children increases continuously (Albon, Hamlin, & Ross, 2010; Andersen, Froberg, Kristensen, Moller, Resaland, & Anderssen, 2010). Many international studies found that BMI is a predictor of the aerobic fitness level (Fogelholm, Stigman, Huisman, & Metsämuuronen, 2008; Hussey, Bell, Bennett, O'Dwyer, & Gormley, 2007; Kerner, Kurrant, & Kalinski, 2004; Magnusson, Sveinsson, Arngrimsson, & Johannson, 2008; Olds, Ridley, & Tomkinson, 2007; Sveinsson, Arngrimsson, & Johannsson, 2009; Tomkinson, Olds, & Borms, 2007). However, when samples were matched for BMI, the decline in PF decreased by approximately 30-60%, but was not eliminated (Olds et al., 2007). Thus, overweight cannot be the only reason for the decline. Another factor might be the increasing consumption of electronic media such as TV or computer. Whereas the relationship between media use and overweight has been shown in several studies (Lampert, Sygusch, & Schlack, 2007; Weber, Hiebl, & Storr, 2008), associations with PF parameters have not been consistently found (Kerner et al., 2004; Marshall, Biddle, Gorely, Cameron, & Murdey, 2004). Also, sports participation has been shown to be an important factor for PF. This holds for leisure time physical activity (PA) (Boreham & Riddoch, 2001; Fogelholm et al., 2008; Hikihara et al., 2007; Kerner et al., 2004; Sacchetti et al., 2012; Sasayama, Okishima, Mizuuchi, & Adaachi, 2009) as well as for sports club practices

(Deutscher Sportbund, 2003; Magnusson et al., 2008). Implications of the outlined secular trend are a reduced physical and athletic capability of a whole generation and increased health risks. Thus, information on the determinants of health behaviors is still fundamental for developing effective behavioral change intervention programs. Here, our research focus is to analyze and compare migration background and language skills (level 1) as predictors to current health-relevant behavioral patterns (level 2) and the longitudinal impact of these patterns on the course of PF over a two-year period (level 3). The model representing this theoretical construct is shown in figure 1. If current behavior predicts the course of PF, behavioral change intervention programs should focus on early adoption. If not, prevention and intervention measures should focus on health behavior adoption and especially on maintenance to steadily preserve health benefits.

----- Figure 1 about here -----

In summary, the objectives of the current paper are to analyze the causes for disparities in PA, BMI, and SB, and their consequences on the course of PF.

Methods

Sample and Study

This study is a community-based, longitudinal study on the course of the PF status of children. Data were collected from 145 primary school children of a middle-sized city in the south of Germany (52.1% male) with an average age of 7.95 years (s = 0.59) at the first time point of measurement. Because of large differences in social levels within the city, three schools were chosen, representing a lower, a medium and a higher social status. After the directors of the schools had agreed to the study, two grade 2 classes within each of the schools were randomly selected. Except for one child, who was excluded from the study, informed consent was obtained from the parents of all designated children. Participants were tested at five measurement points: June 2008, December 2008, June/July 2009, November 2009-January

2010, and June 2010. The protocols were submitted to, and approved by, the institutional ethics committee.

Measurements

Anthropometric data. The children were weighed on a Corona ™ digital scale while wearing their sports clothing but no shoes. The children's standing height was measured with a tape measure fixed to the wall. The body mass index (BMI) was calculated from these two values.

Physical fitness. To test the PF of the children, a standardized test battery, the German Motor Test 6-18, was used. It consists of eight different test items, which are described in detail elsewhere (Bös, 2009). The single test items were as follows: stand-and-reach, 20-meter sprint, balancing backwards on bars of 6 cm, 4.5 cm and 3 cm width, bidirectional jumping in 15 s, sit-ups in 40 s, number of push-ups in 40 s, standing long jump and a 6-minute endurance run. Objectivity (average over the test items: .95) and retest reliability (average over the test items: .82) of the test battery were considered as good, and validity was demonstrated for assessing endurance, strength, flexibility, coordination, and speed (Bös, 2009). The raw test results of every single test item were Z-transformed on the basis of normed samples. Therefore, for every age, a value of 100 represents the average of the norm sample.

Physical activity (PA). In Germany, youth sports activities are mainly practiced in sports clubs or in sports courses in the afternoon or evening. Lacking a validated German questionnaire to access physical activity, we collected the data using a self-administered questionnaire. It consists of an open question ("Which sports do you practice regularly in a sports club or in courses?") followed by an empty weekly schedule, where participants had to fill in their regular weekly sports activities.

Sedentary behavior (SB). In a questionnaire, the children had to report which electronic devices they possess in their children's room, checking a selection from radios, CD players, game consoles, computers or TVs. The operationalization of the SB factor was performed by summing up the latter three large devices, which do not allow much movement. We doubt that to ask children about their daily or weekly time spent with electronic devices provides reliable data. Anyway, at the last point of measurement at the end of the 4th grade we additionally asked for the estimated minutes of daily media consumption. There was a significant but weak positive correlation (r = .381, n = 114, P < .001) between the reported time with the number of electronic devices. We argue that the easy to report number of electronic devices should be a more reliable information than the self-reported time.

Migration background. Participants were defined as immigrants if they or at least one of their parents were not born in Germany.

School achievement. School achievement was assessed based on the grades the pupils received in their reports in the main subject “German language”.

Study design and procedures

Data were collected every six months from June 2008 to June 2010. At each of the five time points of measurement, the staff took the test equipment to the schools. The children of the six classes were tested during their regular sports lessons in school, so they wore their usual sports dress and shoes. Body weight and height were measured without shoes. After five minutes of general warm-up, the children were divided into groups of two or three and completed seven tests in random order. The questionnaire was completed after the body weight measure with the staff’s assistance. The 6-minute endurance run was always performed as the last test in groups of approximately 12 children. All data were recorded by university staff.

Statistical Analysis

For the statistical analysis we used a path model with migration background and school achievement on first level, PA, BMI, and SB on second level, and intercept and slope of the PF on the third level (figure 1). Path analysis along with latent growth curve analysis was conducted with AMOS 18.0 using full information maximum likelihood algorithm (FIML). We used latent growth curve (LGC) analysis because different change trajectories can be analyzed simultaneously (Martens & Haase, 2006). Assuming multivariate normal distribution of the data and that the data are missing at random or missing completely at random, FIML provides unbiased parameter estimates. Even when the assumption of multivariate normality is violated, FIML provides relatively good estimations compared to deletion or mean imputation methods (Enders & Bandalos, 2001). The proportion of missing item responses for each scale ranged from 0.7% to 46.5%. Overall lack of response was 24.1% (282 of 1168 responses). In addition to the χ^2 test, we also used fit indices for model evaluation. The assessment of the global goodness-of-fit was based on the Root Mean Square Error of Approximation (RMSEA), as recommended by Hu and Bentler (1999) and additionally, on the Comparative Fit Index (CFI), as recommended by Beauducel and Wittmann (2005). According to Hu and Bentler (1999), cut off values of approximately RMSEA ≤ .06 and CFI ≥ .95 are appropriate. Furthermore, all zero-order correlations for the determinants of PF (separately for every single path shown in Figure 1) as well as the parameter estimates for the LGC models of PF will be compared with the estimated parameters of all paths estimated simultaneously for the entire model. For slope calculation, baseline was set at zero and last measurement point was set to one. Finally, aside from the level of significance, the size of the parameters was used for interpretation.

Results

Descriptive data are provided in Table 1.

Table 1 about here

Model Fits

Path and latent growth curve analysis revealed a perfect degree of overall model fit, $\chi^2(30) = 34.64$, $P = .26$, $RMSEA = .033$, 90% confidence interval: .000 - .073, $CFI = .99$.

Loadings and (zero-order) Correlations

Children without immigration background had better grades (a = .26, P < .01; see Table 2) and were more active at baseline (a = -.21, P < .05). While immigration background did not impact SB, SB is higher for children with poorer grades (a =.24, P = .01). Grades were not relevant for PA. Neither grade nor immigration background were associated with BMI. However, it should be noted that both associations were significant on the bivariate analyses. Nevertheless, the differences in path values are low ($\Delta ar_{\text{immigration background on BMI}}$ < .04, $\Delta ar_{\text{grade on BMI}}$ < .05). BMI was higher for higher SB (a = .24; P <. 05) but was not associated with PA. Moreover, PA and SB were not related.

PA at baseline impacted significantly the intercept of PF (the more active, the fitter), but not the slope of PF. However, the intercept and slope path values were comparable high ($a_{intercept}$ = .28, P = .001; a_{slope} = .27, P = .21). This finding could be explained by the higher standard error for the slope; while the intercept estimation paths for all measurement points were fixed, only the path at baseline (set at zero) and the path at last measurement point (set at one) were fixed for latent slope estimation. Thus, as the slope itself indicates that PF improves over the two years, there is evidence that this improvement is higher for more active children at baseline. It is also interesting that on the bivariate analysis, we observed an effect of SB on the intercept of PF (with lower PF for more SB; r = -.23; P < .05) but that this effect diminished in the model analysis (a = -.11; P = .24). This indicates that there is no specific variance of SB (after controlling for BMI) on the intercept of PF. Consequently, the slope of PF was also not affected by SB. While BMI impacted the intercept of PF (a = -.31; P < .001; with lower PF for a higher BMI), BMI did not impact the slope of PF. Finally, the higher the PF at baseline, the less is the progress over the following two years (a = -.44; P = .10). Again, even though this finding was not significant (probably due to the high standard error), the path value is comparably high.

Discussion

The main advantage of our longitudinal study is that we could identify not only factors that impact PF, but also factors that impact the development over the course of two years. We could show that PA has a direct positive influence on PF. The finding that the number of club sport activities has a direct influence on children's PF is consistent with the literature (Boreham & Riddoch, 2001; Deutscher Sportbund, 2003; Fogelholm et al., 2008; Hikihara et al., 2007; Magnusson et al., 2008; Sasayama et al., 2009). In our study, we show that PA has also an effect on the development of PF. The more active the 8 year old children are, the more they will enhance their PF in the next two years, independent of age related developmental improvements. Also, BMI has a direct influence on PF. Higher BMI corresponds with lower fitness values. This is consistent with previous studies (Castro-Piñero et al., 2010; Fogelholm et al., 2008; Hussey et al., 2007; Olds, Tomkinson, Léger & Cazola, 2006; Sveinsson et al., 2009). But, contrary to PA, BMI of the 8 year olds has no impact on the development of PF in the next two years.

This finding is supported by the fact that an association between PA and BMI was not found. For the age group of our sample, this confirms the results of some authors (Hume et al., 2008; Ortega et al., 2010), whereas other authors found relationships between PA and BMI (Boreham & Riddoch, 2001, only for boys: Hussey et al., 2007). In our sample, the percentage of overweight (including obesity), which was more than 25% of the 8-year-old boys and approximately 20% of the girls, was relatively high for German children (Kurth & Schaffrath Rosario, 2007). Underweight status was not a widespread problem for boys and girls in primary school in our sample. Based on the investigation of the causes for overweight, our model showed that it is mainly the common variance between migration background and grade in German language class influencing the BMI. Another factor for a higher BMI was the media equipment in the children's room. Almost every second 8-year-old child had a TV, a computer, or a game console in the children's room. Interestingly, no associations were found between migration background and the presence of media equipment, but there was an association between the grade in German and the presence of media equipment in the children's room. One explanation might be that because of language problems, children might spend more time in front of game consoles, computers, and TV, which in return hinders their ability to communicate in German. Based on bivariate analyses, we show that if children possess many electronic devices that hinder movement at the age of 8, this has a negative effect on PF. However, this effect is combined with the higher BMI of children with higher media equipment.

Moreover we found that the migration background of the children was a factor that influenced PA. As we did not find that the grade in German language class influenced PA, it seems to be a cultural problem that immigrant children do not use the opportunities for sports club participation in the same way as non-immigrants.

Caveats

The choice of a questionnaire as an instrument for assessment of PA and media consumption for 8 to 10-year-old children can be viewed critically. However, the design with checkboxes for media equipment and the time-table for club sport activities turned out to be easily handled by the children. Additionally, university staff helped whenever the children had any questions. Concerning the sample size, the dropout rate within two years cannot be neglected, even if the sample was school classes that usually stay together during the time span of primary school in Germany. The reasons were diverse but reasonable: some children moved, some had to repeat a year, and some were injured or ill during the testing.

Conclusions

The main conclusion of our study is that the path is set for children's physical fitness at the age of 8 years at the latest. Although BMI has an impact on the current PF it is not a predictor for the further development of PF. Strongest influence on this development is PA. Sedentary behavior, operationalized by the number of electronic devices in the children's room, can predict not only the state of physical fitness at the current point in time, but also two years later, a lower state of physical fitness is more probable if a sedentary behavior can be observed two years before. Given the fact that physically active children show a better physical fitness than children with an increased sedentary behavior, it makes sense to conclude that increased incentives for physical activities and a constriction of sedentary behavior leads to an increased physical fitness, because a low PF must be considered a risk factor for health (Martins, Silva, Gaya, Aires, Ribeiro, & Mota, 2010; Ruiz, Ortega, Meusel, & Sjöström, 2007). A special focus should be directed to children with immigration background. Sport clubs should increase their attractiveness for this target group. Moreover, measures to end the vicious circle of low language competence and sedentary behavior in front of electronic devices should be established.

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Table 1. *Anthropometric data, weekly club sport activities, and media equipment in the children's room at baseline (June 2008), and physical fitness of the children over the five time points of measurement (T1-T5).*

	All		Girls		Boys	
	Sample size	Mean (SD) //%	Sample size	Mean (SD) //%	Sample size	Mean (SD) //%
Age (years)	122	7.9 (0.6)	65	7.9 (0.5)	69	8.0 (0.6)
Immigration Background	144	50	69	52.2	75	48.0
Grade	127	2.8 (1.2)	63	2.5 (1.2)	64	3.1 (1.1)
BMI	116	17.1 (3.0)	59	16.9 (3.1)	57	17.3 (2.9)
underweight		5.2		6.8		1.8
normal weight		71.6		71.2		71.9
overweight*		13.8		11.9		15.8
obese		9.5		8.5		10.5
Club sport activities	122		60		62	
none		37.7		38.3		37.1
1/week		20.5		28.3		12.9
2/week		21.3		13.3		29.0
3/week		18.9		20.0		17.7
>=4/week		1.6		0.0		3.2
Media equipment	122		60		62	
none		54.1		53.3		54.8
1 device		27.9		30.0		25.8
2 devices		9.0		8.3		9.7
3 devices		9.0		8.3		9.7
Physical fitness T1	115	830 (53)	59	838 (50)	56	822 (56)
Physical fitness T2	107	833 (53)	54	832 (52)	53	834 (55)
Physical fitness T3	114	833 (57)	56	840 (59)	58	826 (63)
Physical fitness T4	99	836 (59)	51	835 (54)	48	838 (55)
Physical fitness T5	102	839 (53)	53	844 (52)	49	835 (56)

*not including obese

Note. Media equipment: number of devices out of a choice of TV, game console, and computer. Physical fitness: sum score of 8 test items. Abbreviations: BMI = body mass index; T1= baseline = June 2008, T2 = Dec 2008, T3 = Jun/Jul 2009, T4 = Nov 2009-Jan 2010, T5 = Jun 2010, SD: standard deviation.

Table 2. *Zero-order correlations, path values and explained variance*

	1		2		3		4		5		6		7		R^2
	a	r	a	r	a	r	a	r	a	r	a	r	a	r	
1 MIG	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2 GRADE	.26[1]	.26	-	-	-	-	-	-	-	-	-	-	-	-	-
3 PA	-.21[1]	-.23	.06	-.15	-	-	-	-	-	-	-	-	-	-	.07
4 SB	.06	.12	.24	.25	.03	-.03	-	-	-	-	-	-	-	-	.07
5 BMI	.16	.20[1]	.16	.21	-.01	-.5	.24[1]	.29[2]	-	-	-	-	-	-	.07
6 IPF	-	-	-	-	.28[3]	.34	-.11	-.23[1]	-.31[3]	.38	-	-	-	-	.22
7 SPF	-	-	-	-	.27	-	-.19	-	-.07	-	-.44	-.29	-	-	.13
8 PF1	-	-	-	-	-	-	-	-	-	-	.92	-	.00	-	-
9 PF2	-	-	-	-	-	-	-	-	-	-	.93	-	.09	-	-
10 PF3	-	-	-	-	-	-	-	-	-	-	.93	-	.10	-	-
11 PF4	-	-	-	-	-	-	-	-	-	-	.94	-	.19	-	-
12 PF5	-	-	-	-	-	-	-	-	-	-	.93	-	.30	-	-

Note. a = path values of Figure 1, r = zero-order correlations for Figure 1, MIG = migration background, PA = physical activity, SB = sedentary behavior, BMI = body mass index IPF = intercept for physical fitness, SPF = slope for physical fitness, PF1 = physical fitness June 2008, PF2 = physical fitness Dec 2008, PF3 = physical fitness Jun/Jul 2009, PF4 = physical fitness Nov 2009-Jan 2010, PF5 = physical fitness Jun 2010, R^2 = size of explained variance (small effect: .02, moderate effect: .13, strong effect: .26; Cohen, 1988) [1]$p < .05$. [2]$p < .01$. [3]$p < .001$.

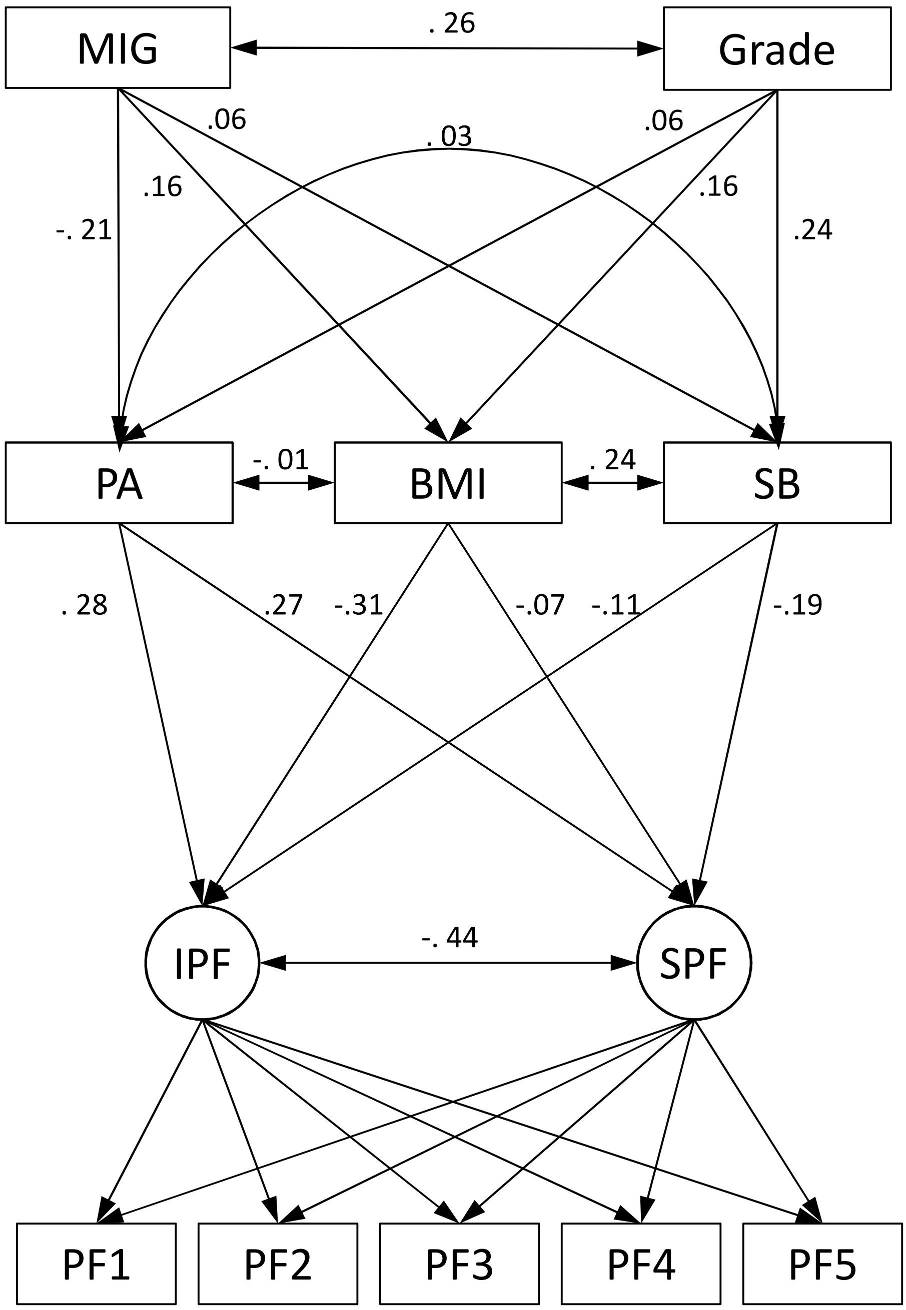

Figure 1. Model to analyse the causes for disparities in PA, BMI, and SB, and their consequences on the course of PF. MIG, migration background; PA, physical activity; BMI, body mass index; SB, sedentary behaviour; IPF, intercept physical fitness; SPF, slope physical fitness; PF1 to PF5, physical fitness at measurements 1 to 5 (see text).