Title: Seasonal Variations in Physical Fitness among Elementary School Children

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Abstract

There is empirical evidence that children's physical activity is dependent on climatic conditions. In addition, a correlation between physical activity level and physical fitness has been identified. In this longitudinal study, we investigate whether seasons have an influence on physical fitness. 145 German elementary school children were tested every six months over a 2-year period. We used the German Motor Test 6-18 to assess physical fitness. Performance in the 6-minute endurance run ($p < .001$), bidirectional jumping ($p < .001$), the standing long jump ($p = .026$), the 20 m sprint ($p = .006$), and the stand-and-reach task ($p = .017$) was significantly better in the summer than in the winter. There were no differences in ability to balance backwards ($p = .120$); in the winter, the results for push-ups ($p < .001$) and sit-ups ($p < .001$) were better than in the summer. We have shown that physical fitness is significantly influenced by the season. Consequently, when children's fitness tests are used (e.g., as the basis for intervention programs, for classifying health risk groups or for recognising talent), the season in which testing occurred should be reported and accounted for in future studies.

Keywords: physical fitness, primary school children, German Motor Test, gender, longitudinal study

Introduction

Physical fitness is an important aspect of human development. Specific attention is paid to the physical fitness of children. Physical fitness enables a healthy lifestyle and allows children to participate in sports. Health care organisations are concerned about the physical fitness of children in each new cohort, sport organisations want to maximise the abilities of youth, and school administrators want to evaluate the effectiveness of sports lessons. Because of the importance of physical fitness, many different tests have been developed over the last half-century (e.g., Morrow, Zhu, Franks, Meredith, & Spain, 2009). To assess an individual's physical fitness level, the individual's scores must be compared with scores from a norming sample. In this article, we investigate whether the scores on physical fitness tests are influenced by the season in which they are measured. We argue that the amount of physical activity (PA) that children perform depends on the season; moreover, some parameters of physical fitness co-vary with PA. Thus, it might be possible that physical fitness test scores – both for individuals and for the norming sample – are dependent on the time of year in which they were assessed.

Several studies have shown that PA has an influence on physical fitness. Children with higher PA levels have better total scores in physical fitness (Castelli & Valley, 2007; Fogelholm, Stigman, Huisman, & Metsämuuronen, 2008; Hikihara et al., 2007; Hume et al., 2008; Sasayama, Okishima, Mizuuchi, & Adachi, 2009; Williams et al., 2008; Wrotniak, Epstein, Dorn, Jones, & Kondilis, 2006). However, most authors do not only analyse total physical fitness scores; they also distinguish between subdomains. Depending on the focus of the study, different aspects of physical fitness are assessed. To focus on abilities, it is common to address the subdomains of aerobic fitness or endurance, strength, speed, flexibility, and coordination. To focus on fundamental motor skills, the common subdomains are locomotion and object-control. The most frequently studied subdomain is aerobic fitness because it often serves as an indicator for children's health. In a review, Boreham and Riddoch (2001) revealed that more active children display healthier cardiovascular profiles. Several other recent studies consistently reported positive correlations between PA and aerobic fitness (Castelli & Valley, 2007; Dencker et al., 2006; Fogelholm et al., 2008; Hands, Larkin, Parker, Straker, & Perry, 2009; Hussey, Bell, Bennett, O'Dwyer, & Gormley, 2007; Kristensen et al., 2010; Magnusson, Sveinsson, Arngrimsson, & Johannsson, 2008; Sasayama et al., 2009). Measuring locomotor skills as a subdomain also reveals consistent advantages for more active children (Hume et al., 2008; Williams et al., 2008). Several major studies have reported correlations between a higher PA level and jumping (standing long jump, 5-jump, jumping side-to-side, jumping back-and-forth) or sprinting (Fogelholm et al., 2008; Hikahara et al., 2007; Sacchetti et al., 2012; Sasayama et al., 2009).

The correlations between other subdomains and PA, however, are not always so clear. Some researchers have found correlations between PA and object-control skills (Fogelholm et al., 2008; Sasayama et al., 2009); others have not (Williams et al., 2008). Some have found correlations only among boys (Cliff, Okely, Smith, & McKeen, 2009; Hume et al., 2008), or stronger correlations for boys than for girls (Hikihara et al., 2007). In addition, for strength and muscle endurance, the findings are ambiguous. Whereas some studies reveal strong correlations between PA levels and tasks such as curl-ups, sit-ups, push-ups, or grip strength (Castelli & Valley, 2007; Fogelholm et al., 2008), others found no correlations (Hands et al., 2009; Hikahara et al., 2007) or correlations among boys but not among girls (Sasayama et al., 2009). One study even found a negative correlation with upper body strength (Hands et al., 2009). Again, no clear correlation could be found between flexibility and children’s PA level; the results differed depending on age, gender, and assessment method (Castelli & Valley, 2007; Fogelholm et al., 2008; Hands et al., 2009; Hikahara et al., 2007; Sacchetti et al., 2012; Sasayama et al., 2009). Potential causes for the ambiguous results might be the differing measurements in PA and physical fitness assessment across the studies. PA assessment methods ranged from self-reports like 7-day physical activity recall (Castelli & Valley, 2007), physical activity questionnaires (Sacchetti et al., 2012) or reports on frequency and duration of sweating during organized and non-organized activity (Fogelholm et al., 2008), to objective measures like pedometers (Castelli & Valley, 2007; Hands et al., 2009) or accelerometers (Hikahara et al., 2007; Sasayama et al., 2009). Likewise, physical fitness parameters were measured with different tests in almost every study. Nevertheless, we summarise that certain subdomains of physical fitness, such as aerobic fitness and locomotor skills, are evidently correlated with PA.

PA is subject to seasonal fluctuations. Recently, research has focused on the influence of the season and weather conditions on PA. In a systematic review, Tucker and Gilliland (2007) analysed 37 studies conducted between 1980 and 2006, including more than a quarter of a million participants in total. According to their analysis, seasonality had an effect on PA level. For adults, men and women had higher levels of PA in the summer than in the winter (Matthews et al., 2001). In some countries, pre-schoolers and elementary school children participate in more PA in warmer months than in colder months (North Canada: Carson, Spence, Cutumisu, Boule, & Edwards, 2010; UK: Rowlands, Pilgrim, & Eston, 2009; Denmark: Kristensen et al., 2008; Norway: Kolle, Steene-Johannessen, Andersen, & Anderssen, 2009). However, for adolescents, there was no clear relationship between the seasons and PA (Denmark: Kristensen et al., 2008; Norway: Kolle et al., 2009; Cyprus: Loucaides, Chedzoy, & Bennett, 2003; Canada: Bélanger, Gray-Donald, O'Loughlin, Paradis, & Hanley, 2009).

Analysing PA by gender reveals that boys are usually more physically active than girls (Baranowski, Thompson, DuRant, Baranowski, & Puhl, 1993; Beighle, Alderman, Morgan, & Le Masurier, 2008; Dencker et al., 2006; Hume et al., 2008; Hussey et al., 2007; Kristensen et al., 2008; Loucaides et al., 2003; Magnusson et al., 2008; Peiró-Velert, Devís-Devís, Beltrán-Carrillo, & Fox, 2008; Rowlands & Eston, 2005; Sasayama et al., 2009). Interestingly, interactions between gender and season have been found among pre-schoolers (Baranowski et al., 1993) and elementary school children (Beighle et al. 2008), indicating that there is less of a difference between the PA levels of boys and girls in the winter than in the spring and summer. In summary, Rowlands and

Hughes' (2006) suggestion to measure PA at multiple time points to account for seasonal variation should certainly be followed.

Given the influence of seasons on PA and the correlations between PA and some subdomains of physical fitness, it seems plausible that seasons have an effect on physical fitness (see Figure 1). The objective of the present study is to test a hypothesis about the influence of the seasons on tests of physical fitness.

Methods

To assess the influence of seasons on physical fitness, we conducted a panel study in which we tested the participants' physical fitness over a two-year time period.

Participants

A total of 145 children participated in the tests. The sample size varied between 114 and 145, with an approximately equal number of boys and girls, over the five data collection points (see Table 1). The average age of all participating children at the time of the first measurement in grade 2 was 7.9 years (SD = ±0.59); at the end of grade 4, the average age was 9.9 years (SD = ±0.60). The children were recruited from three elementary schools in Augsburg, Germany. Two classes from each school were randomly selected. The directors of the schools agreed to participate in the study. Except for the parents of one child who was excluded from the study, informed consent was obtained from the parents of all the selected children. All procedures were approved by the local ethical commission for research on human participants.

Measures

Physical fitness. To test the physical fitness of the children, we used the German Motor Test 6-18, a standardised test battery (Bös, 2009) , which is performed indoors. It consists of eight items that test different subdomains of physical fitness. To assess children's flexibility, the stand-and-reach test was performed. The children were asked to stand on a bench, bend forward with straight legs, and reach down as far as possible. To measure speed, a 20-meter sprint was performed from an upright start position. In German literature, coordination is differentiated into two subcategories, coordination under time pressure and coordination in a task requiring precision (Bös, 2009). The task used for the latter required the children to balance backwards on bars that were 6 cm, 4.5 cm, and 3 cm in width. The children had two attempts to take a maximum of 8 steps on each bar without touching the floor. Coordination under time pressure was measured with a bidirectional jumping task. The children had to jump sideways within two marked fields (50 cm x 50 cm) as many times as possible in 15 sec. To assess strength endurance, two tests were performed: sit-ups for 40 sec and push-ups for 40 sec. The sit-ups were performed in a very common way, but the push-up task had two special characteristics. First, the participants began each push-up lying flat on the floor with both hands touching their back. Second, in the "up" position, the participants had to lift one hand off the floor and touch the other hand. Using this method ensured that every push-up was completed and that no shortcuts were taken. However, it also added a coordination aspect to the task. Power was assessed with the standing long jump. The test for aerobic fitness in the German Motor Test is a 6-minute endurance run in which children run steadily around a volleyball court. Details about the test battery have been described by Bös (2009). The objectivity (average over the items: .95) and retest reliability (average over the items: .82) of the test battery were good, and the battery has been validated for assessing endurance, strength, flexibility, coordination, and speed (Bös, 2009).

Seasons. Augsburg is a city in southern Germany located at 48° 22′ N latitude and 10° 54′ E longitude. The climate is a hybrid of the humid Atlantic climate and the dry continental climate. The region experiences four seasons with average temperatures of 8.0° C in spring (March to May), 16.7° C in summer (June to August), 8.5° C in fall (September to November), and -0.4° C in winter (December to February) (Stadt Augsburg, 2010). For the study, seasonal variations between summer and winter were tested. The measurements in the summer followed the months May/June with mean temperatures of about 14 to 17° C, the measurements in the winter followed the months November/December with mean temperatures of 4 to 0° C.

Study Design and Procedures

The data were collected every six months from June 2008 to June 2010. Of the five measurements three were conducted in the summer (16 – 23 June 2008; 16 June – 07 July 2009; 14 – 17 June 2010) and two in the winter (02 – 18 December 2008; 26 November 2009 –21 January 2010). The children from the six classes were tested during their regular physical education classes in school, so they wore their usual gym clothing and shoes. Body weight and height were measured without shoes. After five minutes of a general warm-up, the children were divided into groups of three, and they completed seven tests in random order. As defined in the test manual (Bös, 2009), the 6-minute endurance run was always performed as the last test in groups of approximately 12 children. All of the data were recorded by trained university staff members.

Data Analysis

Test results were recorded for every test item (see Figure 2). To analyse the differences between the mean test scores at the different points in time and the interaction with gender, a 2-factorial analysis of variance (ANOVA) was calculated with a 5-level within-subject factor (time) and a 2-level between-subjects factor (gender: male, female). To compare physical fitness between different seasons, the data were Z-transformed using the norming sample with analogous age and gender (see Figure 3). This procedure eliminates the improvements in fitness associated with gender and increasing age. To determine the difference in physical fitness between summer and winter, the Z-values of the test items for each of the three measures in summer and for the two measures in winter were summed, and then the averages of the two seasons were calculated. This procedure was chosen, because the aim of the study was not to find differences between single time points of measurement, but across the summer and winter season in general. A two-factorial ANOVA with a two-level within-subject factor (season: summer, winter) and a two-level between-subjects factor (gender: male, female) was conducted to assess whether there were significant differences between physical fitness in summer and winter and to assess the interaction between the season and gender. A significance level of 0.05 was applied for all statistical tests.

Results

Descriptive data for the sample are provided in Table 1. In the investigation period, the children's average height increased by 11 cm, and their weight increased by 8 kg. Between 19% and 25% of the children were classified as overweight during the time of measurement, according to the German norm (Kromeyer-Hauschild et al., 2001). More than half of the children regularly practiced with sports teams or clubs.

Development of physical fitness

The absolute values of the 8 test items over the 5 measurements are shown in Figures 2a-h for boys, girls, and both. The distribution of all 8 test items was Gaussian at every time of measurement (Kolmogorov-Smirnov Statistic). The stand-and-reach test was the only test item without a significant increase in performance over the 2 years (see Figure 2a), ($F(4, 74) = 2.02$, $p = .100$, $\eta^2 = .10$), indicating that flexibility was quite stable throughout elementary school. Except in the first measurement, the girls had significantly higher flexibility scores than the boys. For push-ups and sit-ups, performance improved significantly over the two years ($F(4, 74) = 56.09$, $p < .001$, $\eta^2 = .75$ for push-ups and $F(4, 73) = 20.49$, $p < .001$, $\eta^2 = .53$ for sit-ups). Although there were almost no differences between the boys and the girls for push-ups (see Figure 2b), the boys outperformed the girls in sit-ups in winter 2008, $t(105) = 2.143$, $p = .034$, CI [0.24, 6.03], and in winter 2009, $t(110) = 2.635$, $p = .010$, CI [0.82, 5.81] (see Figure 2c). For the balancing task, we found significant positive development, $F(4, 74) = 14.26$, $p < .001$, $\eta^2 = .44$, with an interaction between time and gender, $F(4, 74) = 2.51$, $p = .049$, $\eta^2 = .12$. The girls performed significantly better than the boys in grade 2 (summer 2008: $t(114) = -2.93$, $p = .004$, CI [-8.31, -1.60]) and grade 3 (winter 2008: $t(105) = -2.02$, $p = .046$, CI [-6.74, -0.67]; summer 2009: $t(112) = -3.56$, $p = .001$, CI [-8.90, -2.53]), but there was no significant difference between the genders in grade 4 (see Figure 2d). The children had the most improvement in bidirectional jumping (see Figure 2e, $F(4, 73) = 107.234$, $p < .001$, $\eta^2 = .855$), over the two years. On this task, the performance of the boys and the girls reached almost identical values over the years in elementary school. Significant improvements also occurred in the standing long jump (see Figure 2f, $F(4, 72) = 7.162$, $p < .001$, $\eta^2 = .285$), with the boys outperforming the girls in grade 3 (winter 2008: $t(105) = 2.06$; $p = .042$, CI [0.00, 0.15]; summer 2009: $t(112) = 2.08$; $p = .040$, CI [0.00, 0.14]). Sprint time to cover 20 m decreased significantly over the two years (see Figure 2g, $F(4, 73) = 10.825$, $p < .001$, $\eta^2 = .372$). The development of speed was very similar between the boys and the girls, but by the end of grade 4, the boys were significantly ahead of the girls, $t(107) = 2.31$; $p = .023$, CI [-0.35, -0.03]). The distance covered in the 6-minute endurance run increased significantly (see Figure 2h, $F(4, 70) = 10.426$, $p < .001$, $\eta^2 = .373$), and there were no interactions with gender.

Seasonal differences

For 5 of the 8 test items, the average summer results were significantly higher than the average winter results. The test with the largest summer advantage was the 6-minute endurance run, ($F(1, 80) = 18.27$, $p < .001$, $\eta^2 = .19$). In this test, we found a significant interaction between the season and gender, $F(1, 80) = 5.22$, $p = .025$, $\eta^2 = .06$. Furthermore, in the summer, the children performed significantly better on the stand-and-reach test ($F(1, 85) = 5.91$, $p = .017$, $\eta^2 = .07$), bidirectional jumping, ($F(1, 84) = 16.33$, $p < .001$, $\eta^2 = .16$), the standing long jump, ($F(1, 83) = 5.14$, $p = .026$, $\eta^2 = .06$), and the 20 m sprint, ($F(1, 85) = 7.91$, $p = .006$, $\eta^2 = .09$). The two tasks requiring strength endurance, push-ups, and sit-ups, were the only tests that were performed significantly better in winter (push-ups: $F(1, 85) = 49.96$, $p < .001$, $\eta^2 = .37$; sit-ups: $F(1, 85) =$

26.14, $p < .001$, $\eta^2 = .24$). Season had no significant influence on balancing performance, $F(1, 86) = 2.47$, $p = .120$, $\eta^2 = .03$. To summarise, seasonal variations in motor test performance were identified in seven out of eight test items. There were better results for push-ups and sit-ups in the winter and better results for the stand-and-reach, bidirectional jumping, the standing long jump, the 20 m sprint, and the 6-min endurance run in the summer (see Figure 3).

Discussion

Fitness subdomains

For some tasks, the Z-scores that the participants obtained were far better than the scores by the norming sample. This difference may have occurred because the participants became more proficient in the coordination tasks over the five measurements. For the strength, endurance, and speed tasks, the performances were similar to the German average. Regarding the fitness test results for the summer and winter measures, we found different effects for the different subdomains of fitness.

Aerobic fitness. A review of the literature suggests that there is a positive correlation between PA and aerobic fitness (Castelli & Valley, 2007; Dencker et al., 2006; Fogelholm et al., 2008; Hands, et al., 2009; Kristensen, et al., 2010; Sasayama, et al., 2009). Therefore, we hypothesised that the children's performances on aerobic fitness tasks would be better in the summer, when children's PA is higher. In accordance with our expectations, the participants in this study had significantly better test scores on the 6-min endurance run in the summer compared to the winter. Concerning gender differences, our results showed that the seasonal effect for this task was even clearer for girls than for boys, although Hussey et al. (2007) did not find a correlation between the endurance test and PA in girls.

Speed. A summer advantage was also apparent in the speed task. Again, this finding was consistent with our expectation, even though the correlation between PA and speed has not been thoroughly explored. Whereas one comprehensive study on Australian 9-12-year-olds revealed correlations between vigorous PA and the sprint run for boys and girls (Hume et al., 2008), other studies have demonstrated positive correlations between greater PA and sprint performance among boys but not among girls (Sacchetti et al., 2012; Sasayama et al., 2009). In our study, the negative influence of winter was very similar for boys and girls.

Power. Most authors found positive correlations between PA and tasks requiring power, such as the standing long jump (Hikihara et al., 2007), the vertical jump (Hume et al., 2008) or the 5-jump (Fogelholm et al., 2008). Our finding that the season significantly influenced performance on the standing long jump is consistent with the existing literature. Again, both boys and girls performed better in the summer than in the winter, although some authors have found that the positive influence of PA only affects standing long jump performance for boys (Sacchetti et al., 2012).

Coordination under time-pressure. Bidirectional jumping is a task that requires coordination under time pressure. Similar tasks, such as the side-step task or back-and-forth jumping, were significantly correlated with PA for both boys and girls (Fogelholm et al., 2008; Hikihara et al., 2007). In our study, the results for bidirectional jumping were significantly better in the summer than in the winter. The girls lost their initial advantage over the boys between grade 2 and grade 4. For this task, the negative influence of winter seemed to be more relevant for the girls.

Coordination requiring precision. Balancing backwards is a task that tests children's ability to achieve coordination with precision (Bös, 2009). In some German studies (Schmidt, 2008), correlations have been shown between children's participation in sports clubs and their balancing performance. To date, however, no international studies have addressed balancing tasks and PA. From a logical point of view, it could be assumed that longer outdoor play times would improve performance in balancing. However, the season did not have a significant influence on performing this task.

Strength endurance. The two tasks testing strength endurance in the present study were push-ups and sit-ups performed for 40 seconds each. As described above, push-ups were performed with special characteristics, adding a coordination aspect. Thus, the sample in this study had very high Z-values for this task compared to the norming sample because a learning effect was evident for this special push-up task over the five points of measurement. Nevertheless, it is surprising that in the comparison of the seasons, children performed significantly better in winter on both strength endurance tasks (push-ups and sit-ups). Previous studies investigating on the effects of PA on these types of tasks have revealed conflicting results. Among children, Castelli and Valley (2007) showed that there were correlations between PA and curl-ups and push-ups, whereas Hikihara et al. (2007) found no correlation with sit-ups. Sasayama et al. (2009) showed a significant correlation between PA and sit-ups for boys but not for girls. In adolescents, Fogelholm et al. (2008) also found a correlation with sit-ups. Hands et al. (2009), however, revealed contrary results. PA was not correlated with abdominal muscle endurance (curl ups), and high levels of PA were negatively correlated with upper body strength (chest pass). Although the findings are inconsistent, the considerable improvements in the winter measures in our study can hardly be explained. A closer look at the data showed that it was mainly the sports club members who improved in the winter, which may be one plausible explanation for this phenomenon.

Flexibility. The flexibility of the elementary school children on the stand-and-reach task was higher in the summer compared to the winter. This result is in alignment with the findings of other authors. For age groups that were similar to the group in our study, PA level has been found to be related to flexibility on the sit-and-reach task (Castelli & Valley, 2007; Hikihara et al., 2007). Some authors, however, have found a correlation only for boys but not for girls (Sasayama et al., 2009), no correlation (Sacchetti et al., 2012) or even a negative correlation (Hands et al., 2009). The latter was contributed to the lower muscle tone of inactive people.

We expected bigger differences between the boys and the girls in summer because of some findings among elementary school children that have shown that there were fewer differences in PA levels of boys and girls in the winter compared to spring and summer (Beighle et al., 2008). This did not occur in our study. The only task with an interaction between season and gender was the 6-min endurance run, but the difference between the boys and the girls was lower in the summer than in the winter.

Caveats

Except for strength endurance and balancing, the physical fitness of the tested children in the summer was better than their physical fitness in the winter. Most of the results were in accordance with our hypotheses. However, the scope of the study still remains to be defined. It seems plausible that the seasonal differences in physical fitness are related to climatic conditions. Presumably, this constrains the scope of our study to areas of latitude in which a seasonal difference between warm summers and cold winters can be observed. Moreover, the observed interactions between gender and season in some of the subdomains of fitness are presumably dependent on cultural concepts of boys and girls playing outdoors.

Conclusions

We have shown that physical fitness depends on the season. However, seasonal influences do not affect all subdomains of physical fitness in the same way. Previous research has shown that higher levels of PA did not result in higher performances in all physical fitness subdomains. Thus, when comparing seasonal influences, researchers must always take into account which physical fitness subdomain is being examined.

When child fitness is compared to norming standards, the season in which the children have been tested should be taken into account. For example, because aerobic fitness is an indicator for health risks, the children would be classified into the risk group because of their conspicuous test result in the endurance run in the winter. Researchers developing test standard values should either consider measures of all seasons or, at least, document when the norm values were collected. The limits used for declaring the needs of intervention programs, for classifying children into health risk groups and for selecting talent must be adapted. When different cohorts are involved in comparisons, the season when the measures were taken should be considered. Otherwise, the differences may be due to seasonal effects rather than to secular trends.

The season seems to have an influence, not only on PA of elementary school children but also on their physical fitness. This fact should be the focus of future studies.

References

Baranowski, T., Thompson, W. O., DuRant, R. H., Baranowski, J., & Puhl, J. (1993). Observations on physical activity in physical locations: age, gender, ethnicity, and month effects. *Research Quarterly for Exercise and Sport, 64*, 127–133.

Beighle, A., Alderman, B., Morgan, C. F., & Le Masurier, G. (2008). Seasonality in children's pedometer-measured PA levels. *Research Quarterly for Exercise and Sport, 79*, 256–260.

Bélanger, M., Gray-Donald, K., O'Loughlin, J., Paradis, G., & Hanley, J. (2009). Influence of weather conditions and season on physical activity in adolescents. *Annals of epidemiology, 19,* 180–186. doi: 10.1016/j.annepidem.2008.12.008

Bös, K. (2009). *Deutscher Motorik Test 6-18 (DMT 6-18)* [German Motor Test 6-18]. Hamburg: Czwalina.

Boreham, C., & Riddoch, C. (2001). The physical activity, fitness and health of children. *Journal of Sports Sciences, 19*, 915–929. doi: 10.1080/026404101317108426

Carson, V., Spence, J. C., Cutumisu, N., Boule, N., & Edwards, J. (2010). Seasonal variation in physical activity among preschool children in a northern Canadian city. *Research Quarterly for Exercise and Sport, 81*, 392–399.

Castelli, D. M., & Valley, J. A. (2007). Chapter 3: The relationship of physical fitness and motor competence to physical activity. *Journal of Teaching in Physical Education*, *26*, 358–374.

Cliff, D. P., Okely, A. D., Smith, L. M., & McKeen, K. (2009). Relationships between fundamental movement skills and objectively measured physical activity in preschool children. *Pediatric Exercise Science, 21*, 436-449.

Dencker, M., Thorsson, O., Karlsson, M., Lindén. C., Svensson, J., & Wollmer, P., Anderson, L. B. (2006). Daily physical activity and its relation to aerobic fitness in children aged 8-11 years. *European Journal of Applied Physiology, 96*, 587–592. doi: 10.1007/s00421-005-0117-1

Fogelholm, M., Stigman, S., Huisman, T., & Metsämuuronen, J. (2008). Physical fitness in adolescents with normal weight and overweight. *Scandinavian Journal of Medicine & Science in Sports, 18*, 162–170. doi: 10.1111/j.1600-0838.2007.00685.x

Hands, B., Larkin, D., Parker, H., Straker, L., & Perry, M. (2009). The relationship among physical activity, motor competence and health-related fitness in 14-year-old adolescents. *Scandinavian Journal of Medicine & Science in Sports*, *19*, 655–663. doi: 10.1111/j.1600-0838.2008.00847.x

Hikihara, Y., Sasayama, K., Okishima, K., Mizuuchi, H., Yoshitake, Y., & Adachi, M., & Takamatsu, K. (2007). The difference of relationships between physical activity variables and physical fitness in children and adolescents: With special reference to amount and intensity of physical activity. *Japanese Journal of Physical Fitness and Sport, 56*, 327–338.

Hume, C., Okely, A., Bagley, S. Telford A., Booth, M., Crawford, D., & Salmon, J. (2008). Does weight status influence associations between children's fundamental movement skills and physical activity? *Research Quarterly for Exercise and Sport*, *79*, 158–165.

Hussey, J., Bell, C., Bennett, K., O'Dwyer, J., & Gormley, J. (2007). Relationship between the intensity of physical activity, inactivity, cardiorespiratory fitness and body composition in 7-10-year-old Dublin children. *British Journal of Sports Medicine, 41*, 311–316. doi: 10.1136/bjsm.2006.032045

Kolle, E., Steene-Johannessen, J., Andersen, L. B., & Anderssen, S. A. (2009). Seasonal variation in objectively assessed physical activity among children and adolescents in Norway: a cross-sectional study. *The International Journal of Behavioral Nutrition and Physical Activity, 6*(36). doi:10.1186/1479-5868-6-36

Kristensen, P., Møller, N. C., Korsholm, L., Kolle, E., Wedderkopp, N., Froberg K., & Andersen, L. B. (2010). The association between aerobic fitness and physical activity in children and adolescents: the European youth heart study. *European Journal of Applied Physiology*, *110,* 267–275. doi: 10.1007/s00421-010-1491-x

Kristensen, P., Korsholm, L., Møller, N. C., Wedderkopp, N., Andersen, L. B., & Froberg K. (2008). Sources of variation in habitual physical activity of children and adolescents: the European youth heart study. *Scandinavian Journal of Medicine & Science in Sports, 18*, 298–308. doi: 10.1111/j.1600-0838.2007.00668.x

Kromeyer-Hauschild, K., Wabitsch, M., Kunze, D., Geller, F., Geiß, H., Hesse, V., …Hebebrand, J. (2001). Perzentile für den Body-Mass-Index für das Kindes- und Jugendalter unter Heranziehung verschiedener deutscher Stichproben [Percentiles for the body-mass-index for children and adolescents consulting different German samples]. *Monatsschrift Kinderheilkunde, 149*, 807-818. doi:10.1007/s001120170107

Loucaides, C. A., Chedzoy, S. M., & Bennett, N. (2003). Pedometer-assessed physical (ambulatory) activity in Cypriot children. *European Physical Education Review*, *9*, 43–55. doi: 10.1177/1356336X03009001179

Magnusson, K., Sveinsson, T., Arngrimsson, S. A., & Johannsson, E. (2008). Predictors of fatness and physical fitness in nine-year-old Icelandic school children. *International Journal of Pediatric Obesity, 3*, 217–225. doi: 10.1080/17477160802169482

Matthews, C. E., Freedson, P. S., Hebert, J. R., Stanek, E. J., Merriam, P. A., & Rosal, M. C., et al. (2001). Seasonal variation in household, occupational, and leisure time physical activity: longitudinal analyses from the seasonal variation of Blood Cholesterol Study 108. *American Journal of Epidemiology, 153*, 172–183. doi: 10.1093/aje/153.2.172

Morrow, J. R., Zhu, W., Franks, B. D., Meredith, M. D., & Spain, C. (2009). 1958-2008: 50 Years of Youth Fitness Tests in the United States. *Research Quarterly for Exercise and Sport, 80,* 1–11.

Peiró-Velert, C., Devís-Devís, J., Beltrán-Carrillo, V., & Fox, K. (2008). Variability of Spanish adolescents' physical activity patterns by seasonality, day of the week and demographic factors. *European Journal of Sport Science, 8*, 163–171. doi: 10.1080/17461390802020868

Rowlands, A. V., & Eston, R. G. (2005). Comparison of accelerometer and pedometer measures of physical activity in boys and girls, ages 8–10 years. *Research Quarterly for Exercise and Sport*, *76*, 251–257.

Rowlands, A. V., & Hughes, D. R. (2006). Variability of physical activity patterns by type of day and season in 8-10-year-old boys. *Research Quarterly for Exercise and Sport, 77*, 391–395.

Rowlands, A. V., Pilgrim, E., & Eston, R. (2009). Seasonal changes in children's physical activity: An examination of group changes, intra-individual variability and consistency in activity pattern across season. *Annals of Human Biology*, *36*, 363–378. doi: 10.1080/03014460902824220

Sacchetti, R., Ceciliani, A., Garulli, A., Masotti, A., Poletti, G., Beltrami, P., & Leoni, E. (2012). Physical fitness of primary school children in relation to overweight prevalence and physical activity habits. *Journal of Sports Sciences, 30*, 633-640. doi: 10.1080/02640414.2012.661070

Sasayama, K., Okishima, K., Mizuuchi, H., & Adachi, M. (2009). Relationship of daily physical activity and fitness in elementary school children. *Japanese Journal of Physical Fitness and Sport, 58*, 259–304.

Schmidt, W. (2008). Zur Bedeutung des Sportvereins im Kindesalter [The importance of sports clubs for children]. In W. Schmidt (Ed.), *Zweiter Deutscher Kinder- und Jugendsportbericht* (pp. 373-390). Schorndorf: Hofmann.

Stadt Augsburg (2010). *Statistisches Jahrbuch der Stadt Augsburg 2009* [Statistical year book of the city of Augsburg 2009]. Retrieved from http://www.augsburg.de/fileadmin/www/dat/01au/statistik/Jahrbuch/2009_Gesamt/Jahrbuch2009_Gesamtausgabe.pdf

Tucker, P., & Gilliland, J. (2007). The effect of season and weather on physical activity: a systematic review. *Public Health, 121*, 909–922. doi: 10.1016/j.puhe.2007.04.009

Williams, H. G., Pfeiffer K. A., O'Neill, J. R., Dowda, M., McIver, K. L., Brown, W. H., & Pate, R. P. (2008). Motor skill performance and physical activity in preschool children. *Obesity*, *16*, 1421–1426. doi:10.1038/oby.2008.214

Wrotniak, B. H., Epstein, L. H., Dorn, J. M., Jones, K. E., & Kondilis V. A. (2006). The relationship between motor proficiency and physical activity in children. *Pediatrics, 118*, 1758–1765. doi:10.1542/*peds*.2006-0742

Table 1. *Demographic Information.*

Variable	T1		T2		T3		T4		T5	
Total # of participants	125		130		134		145		114	
Boys	63		66		69		76		58	
Girls	62		64		65		69		56	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Age years	7.9	.59	8.3	.56	9.0	.59	9.4	.53	9.9	.60
Height cm	131	5.9	134	6.2	137	6.4	140	6.7	142	7.0
Weight kg	29.5	6.7	31.5	7.6	33.6	8.0	36.2	9.3	37.9	9.4
BMI kg/m²	17.1	3.0	17.3	3.1	17.7	3.2	18.3	3.7	18.6	3.8
underweight %	5.2		8.5		5.2		5.3		4.4	
normal weight %	71.6		70.8		75.7		73.5		70.2	
overweight %	23.3		20.8		19.1		21.2		25.4	
Sports club members %	62		59		57		63		65	

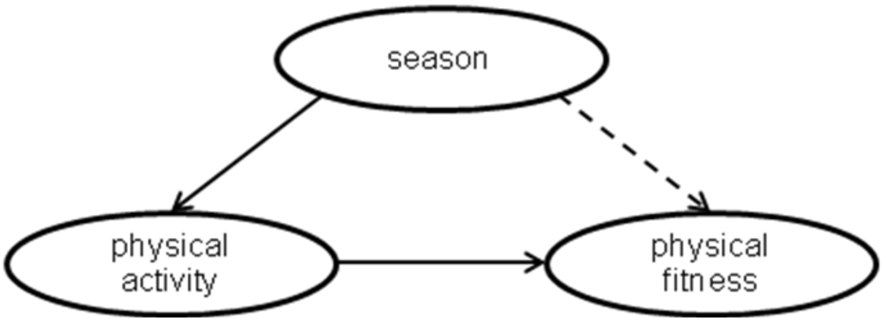

Figure 1. Correlations (continuous lines) and supposed correlations (dashed line) between season, physical activity and physical fitness.

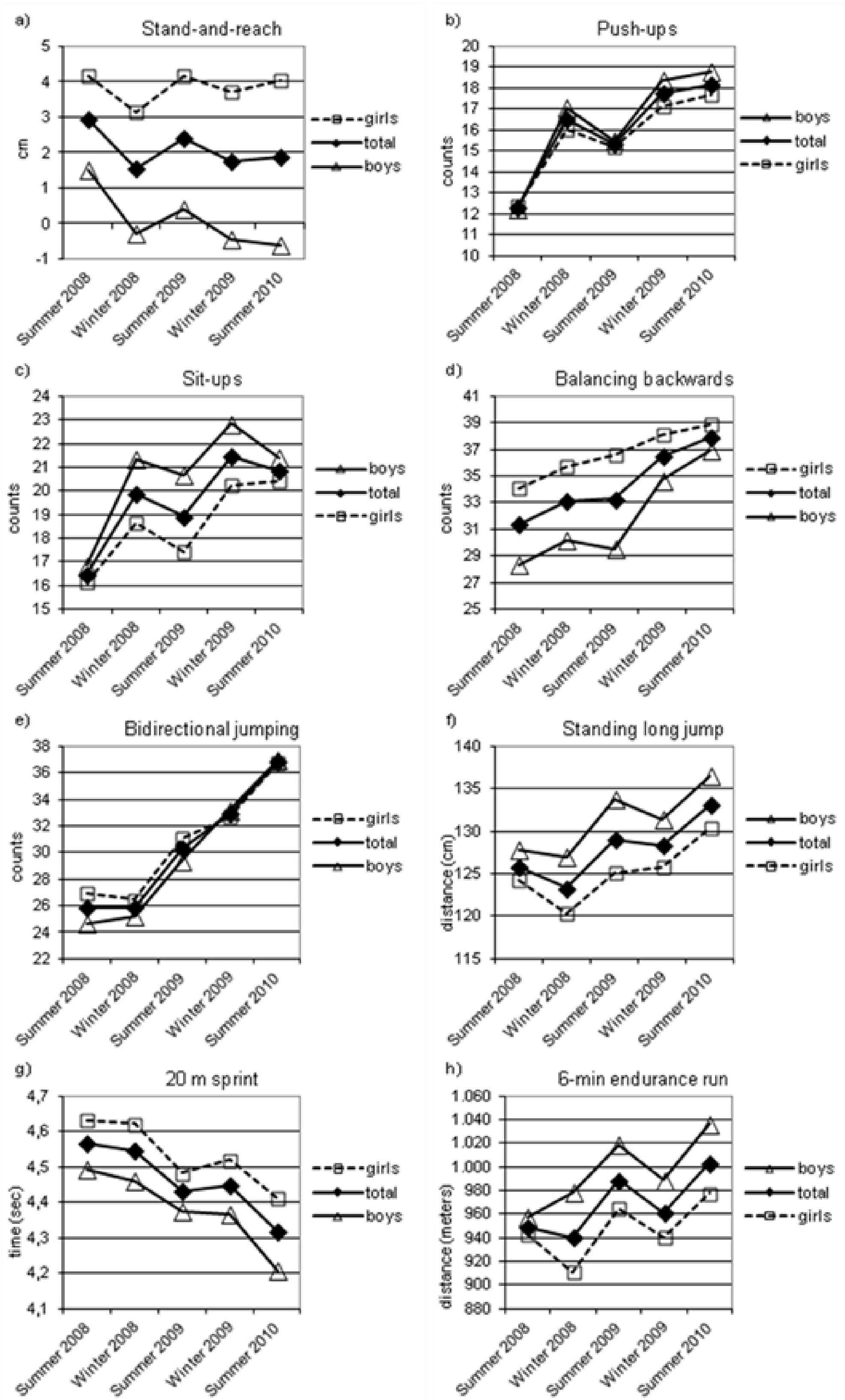

Figure 2a)-h). Scores on the test items of boys and girls over the 5 times of measurement. n_{girls} = 42; a), b), d) n_{boys} = 37; c), e), g) n_{boys} = 36; f) n_{boys} = 35; h) n_{boys} = 33

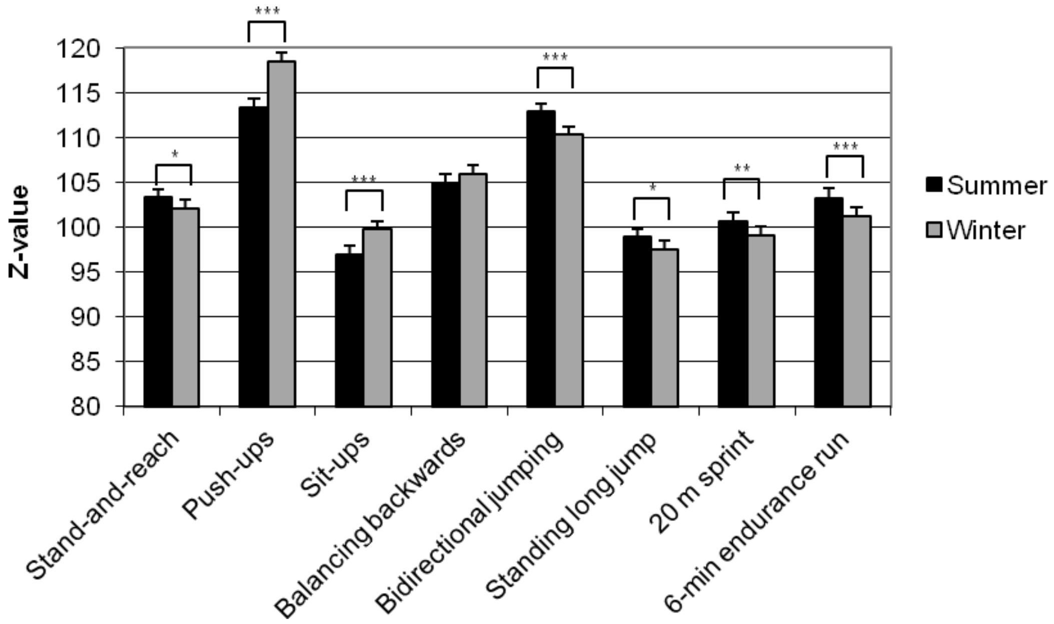

Figure 3. Z-values of the single test items averaged over the season and compared across season. *** $p < .001$, ** $p < .01$, * $p < .05$.

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