Decreased External Skeletal Robustness in Schoolchildren – A Global Trend? Ten Year Comparison of Russian and German Data

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Abstract

Objectives: Obesity and a reduced physical activity are global developments. Physical activity affects the external skeletal robustness which decreased in German children. It was assumed that the negative trend of decreased external skeletal robustness can be found in other countries. Therefore anthropometric data of Russian and German children from the years 2000 and 2010 were compared.

Methods: Russian (2000/2010 n = 1023/268) and German (2000/2010 n = 2103/1750) children aged 6–10 years were investigated. Height, BMI and external skeletal robustness (Frame-Index) were examined and compared for the years and the countries. Statistical analysis was performed by Mann-Whitney-Test.

Results: Comparison 2010 and 2000: In Russian children BMI was significantly higher; boys were significantly taller and exhibited a decreased Frame-Index (p = .001) in 2010. German boys showed significantly higher BMI in 2010. In both sexes Frame-Index (p = .001) was reduced in 2010. Comparison Russian and German children in 2000: BMI, height and Frame-Index were different between Russian and German children. German children were significantly taller but exhibited a lower Frame-Index (p<.001). Even German girls showed a significantly higher BMI. Comparison Russian and German children in 2010: BMI and Frame-Index were different. Russian children displayed a higher Frame-Index (p<.001) compared with Germans.

Conclusions: In Russian children BMI has increased in recent years. Frame-Index is still higher in Russian children compared with Germans however in Russian boys Frame-Index is reduced. This trend and the physical activity should be observed in the future.

Introduction

The globalisation leads to intensification of relationships between individuals and countries on an economic, political and cultural base. Changes of lifestyle, food systems and dietary habits are the consequences. The nutrition transition gets to increased energy intake and with the advancement of techniques physical activity decreases. The result is an imbalance of energy intake and consumption which leads to obesity in children and adults in industrial, emergent and developing countries [1].

Worldwide, the physical activity is lower than a few years ago and the reasons for that development are various. Ten year comparisons showed that the physical fitness which is a result of physical activity is reduced in British children and in Czech Republic adolescents [2], [3]. In Germans, only 13.1% of girls and 17.4% of boys were 60 min/day physically active [4]. In a country comparison between children from Greece, Netherland, Belgium, Switzerland and Hungary only 4.6% of girls and 16.8% of boys reached the level of 60 min/day. Swiss children are more physically active than their contemporaries from the other countries [5]. Furthermore, it was represented that Russian children performed better fitness tests than Americans. Russian children spent more time in structured training sports clubs and walk to and from school [6]. Probably, a development which has been enforced from the end of the 90th where only 33% of the Russian households held a car and no school busses were available, so 92% of the children went to school by walking [7]. In other countries as US, Canada, UK and Australia active commuting decreased in the last years which, however, might be a factor to raise daily physical activity [8], [9], [10]. Even media consumption as a consequence thereof sedentary behaviour is increasing [11]. Further, children in Eastern European states with a low social-economic status also spent more time with TV viewing and they participated in the sports club less frequently with the result of lower physical activity [12], [13].

Reduced physical activity is not only one of the reasons for obesity but also affects external skeletal robustness which is decreased [14], [15]. A ten year comparison showed that new trend in German 6–12 years-olds boys and girls [16]. However,
physical activity is needed to boost the bone growth beside calcium intake especially at an early age [17], [18], [19]. Children with a decreased external skeletal robustness will have it their whole lifetime. When they are seniors and especially overweight the prevalence of joint diseases and osteoporosis may increase. This would result in a high cost factor for the health system.

In that context questions arise whether that negative trend of decreased external skeletal robustness is a global development such as obesity and how the trend proceeds as compared to other countries. In this study anthropometric data of German children were compared with data of Russian children from 2000 and 2010. Due to the globalisation, the political development, the lower physical activity in Eastern Europe states and the fact that Russian children are fitter than the American children we suggest that the negative changes reach the Russian population after a time delay. We assumed differences between Russian and German data in 2000 and an approach in 2010.

**Materials and Methods**

**Ethics statement**

Investigations were approved by relevant institutions: Senate Department of Education, Science and Research Berlin (Permit number: VI D 1), Ministry of Education, Youth and Sports Brandenburg (Permit number: 60/2010) and Department of Education of Moscow city. The study was implemented on a voluntary basis with parents’ permission. They signed a written informed consent but finally the children should agree with participation as well. All data was anonymized.

**Samples**

In Russia and Germany children aged from 6 to 10 completed years were anthropometric examined in 2000 and 2010. Allocation of samples in sex and nationality is represented in Table 1. Measurements were taken at elementary schools in Moscow (Russia), Brandenburg and Berlin (Germany). Schools

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**Table 1. Sample allocation of Russian and German children 2000/2010.**

| age | year/country/sex | Russian boys | Russian girls |
|-----|------------------|--------------|---------------|
|     | 2000             |              |               |
|     | Russian all      | 69           | 267           |
|     | Russian girls    | 38           | 117           |
|     | Russian boys     | 31           | 150           |
|     | German all       | 407          | 333           |
|     | German girls     | 177          | 175           |
|     | German boys      | 230          | 158           |
|     | 2010             |              |               |
|     | Russian all      | 3            | 93            |
|     | Russian girls    | 0            | 44            |
|     | Russian boys     | 3            | 49            |
|     | German all       | 226          | 407           |
|     | German girls     | 121          | 204           |
|     | German boys      | 105          | 203           |

**Table 2. P50 and mean values ± standard deviation of the parameters BMI (kg/m²), Frame-Index, height (cm) of Russian boys and girls from the years 2000 and 2010.**

| parameter | Russian boys | 2000 | 2010 | Russian girls | 2000 | 2010 |
|-----------|--------------|------|------|---------------|------|------|
| BMI       | p50          | Mean ± SD | p50 | Mean ± SD | p50 | Mean ± SD | p50 | Mean ± SD |
| all       | 16.21        | 16.67±2.16 | 16.82 | 17.48±2.57 | 15.99 | 16.34±2.15 | 16.79 | 17.29±2.65 |
| Frame-Index | 42.1 | 42.06±1.91 | 41.41 | 41.48±1.87 | 40.17 | 40.22±2.03 | 40.15 | 40.51±2.14 |
| height    | 132.7        | 132.17±8.06 | 134.7 | 134.2±8.27 | 132.1 | 131.86±7.69 | 131.5 | 132.05±8.57 |
| age       | 6             | BMI       | 15.82 | 15.93±1.52 | 15.9 | 15.89±1.92 | 15.91 | 15.89±1.92 |
| Frame-Index | 42.59 | 42.43±1.56 | / | / | 41.14 | 41.43±1.74 | / | / |
| height    | 122.9        | 122.41±4.11 | / | / | 121.6 | 122.87±4.59 | / | / |
| age       | 7             | BMI       | 15.7 | 16.2±2.05 | 16.33 | 16.72±2.1 | 15.89 | 16.02±1.96 | 17.06 | 17.18±2.53 |
| Frame-Index | 42.29 | 42.2±1.97 | 41.5 | 41.68±1.93 | 40.38 | 40.42±2.01 | 40.61 | 40.89±2.06 |
| height    | 126.2        | 125.59±5.36 | 127.7 | 128.28±5.67 | 126.2 | 126.72±5.4 | 125.2 | 126.14±5.76 |
| age       | 8             | BMI       | 16.38 | 16.05±1.97 | 16.52 | 17.22±2.44 | 16.11 | 16.3±2.14 | 16.78 | 17.19±2.37 |
| Frame-Index | 41.82 | 41.83±1.9 | 41.63 | 41.69±1.58 | 39.82 | 40.2±2.13 | 39.74 | 40.34±2.44 |
| height    | 132.9        | 132.18±5.89 | 131.8 | 131.74±6.8 | 132.6 | 131.81±5.91 | 130.5 | 130.62±5.56 |
| age       | 9             | BMI       | 16.56 | 17.01±2.22 | 17.86 | 18.24±3.18 | 16.25 | 16.07±2.38 | 16.67 | 16.72±2.24 |
| Frame-Index | 41.9 | 42.04±1.9 | 40.86 | 41.09±2.02 | 40.18 | 39.95±2.01 | 40.15 | 40.29±2.07 |
| height    | 137.1        | 136.75±5.64 | 140.4 | 140.54±6.34 | 137.5 | 136.32±6.39 | 135.4 | 137.26±6.95 |
| age       | 10            | BMI       | 16.93 | 17.79±2.51 | 18.1 | 18.15±2.39 | 15.98 | 16.32±2.19 | 17.37 | 18.45±3.63 |
| Frame-Index | 41.9 | 42.09±1.99 | 41.72 | 41.52±1.94 | 39.88 | 40.03±1.70 | 39.75 | 40.11±1.79 |
| height    | 142.2        | 142.01±5.56 | 139.4 | 140.51±5.93 | 138.8 | 139.65±5.2 | 142.6 | 143.06±6.46 |
were from different districts therefore children were from varying social backgrounds.

**Anthropometric measurements**

Anthropometric measurements were followed by standardized methods in a standing position with prescribed measuring instruments [20]. The anthropometric parameters height, weight and elbow breadth were taken. By means of this, the following indices were calculated and compared:

1. **Body Mass Index**

\[
\text{BMI} = \frac{\text{weight in kg}}{\text{height in m}^2}
\]

**Table 3.** Data comparison of the parameters BMI (kg/m²), Frame-Index, height (cm) of the years 2000 and 2010 for Russian and German boys and girls children.

|       | 2000 vs. 2010 |  |  |  |  |  |
|-------|---------------|---|---|---|---|---|
|       | Russian boys  | Russian girls | German boys | German girls |
| age   | parameter     | U  | p      | U  | p      | U  | p      |
| all   | BMI           | 33535 | <.001*** | 21732 | <.001*** | 410562 | .002** | 464152 | .528 |
|       | Frame-Index   | 26055 | .002** | 20883 | .290 | 406989 | .001*** | 433953 | .002** |
|       | height        | 36769 | .034*   | 26683 | .530 | 436508 | .355 | 430634 | .001** |
| 6     | BMI           | n.d.a | n.d.a  | n.d.a | n.d.a  | 10556 | .065  | 10260 | .621 |
|       | Frame-Index   | n.d.a | n.d.a  | n.d.a | n.d.a  | 10810 | .139  | 8912 | .014* |
|       | height        | n.d.a | n.d.a  | n.d.a | n.d.a  | 11537 | .513  | 10668 | .956 |
| 7     | BMI           | 2830 | .016*   | 1941 | .016*  | 15981 | .955  | 17115 | .490 |
|       | Frame-Index   | 2251 | .115   | 1929 | .241 | 14228 | .066  | 17124 | .495 |
|       | height        | 2883 | .024*   | 2417 | .553 | 15110 | .346  | 16894 | .369 |
| 8     | BMI           | 2199 | .292   | 1764 | .050  | 11903 | .024*  | 19082 | .109 |
|       | Frame-Index   | 1976 | .756   | 1572 | .519  | 13885 | .812  | 20215 | .564 |
|       | height        | 2244 | .376   | 1891 | .146  | 12969 | .293  | 16748 | <.001*** |
| 9     | BMI           | 2301 | .026*   | 1190 | .819  | 23423 | .104  | 24263 | .180 |
|       | Frame-Index   | 1541 | .009**  | 958  | .574  | 21648 | .004** | 23701 | .082 |
|       | height        | 1940 | .001**  | 1216 | .892  | 24386 | .349  | 24640 | .282 |
| 10    | BMI           | 708  | .175   | 419  | .048*  | 19817 | .268  | 16885 | .017* |
|       | Frame-Index   | 553  | .363   | 420  | .766  | 19028 | .079  | 17776 | .105 |
|       | height        | 679  | .109   | 430  | .064  | 18802 | .052  | 17802 | .110 |

U = Mann-Whitney-Test.
p = p-value. significant in bold.
significance levels = p.<.001 (***) , p.<.01 (**), p.<.05 (*).
n.d.a = no data available for Russian children.
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2. External skeletal robustness [21]

\[
\text{Frame} - \text{Index} = \frac{(\text{elbow breadth in mm} \times 100)}{(\text{height in cm})}
\]

Through these Index it can be concluded on external skeletal robustness. Three types small, medium and large frame size can be realized by creating percentile curves. However, to analyse Frame-Index 3rd, 10th, 50th, 90th and 97th percentiles were calculated and the curves were smoothed with LMS method [22]. We used these percentiles due to the 3rd and 10th percentiles showed significant differences in German children in the years 2000 and 2010 [16]. Although sample size was small in Russian children in 2010 these percentiles were applied for the comparison.

Statistical analysis

Samples sizes of the different years 2000/2010 and States Russian/German differ greatly (Table 1). Data was partly not normally distributed which showed the Kolmogorov-Smirnov test.

Table 4. P50 and mean values ± standard deviation of the parameters BMI (kg/m²), Frame-Index, height (cm) of German boys and girls from the years 2000 and 2010.

|               | German boys |         |          |               |         |          |               |         |          |
|---------------|-------------|---------|----------|---------------|---------|----------|---------------|---------|----------|
|               | 2000        | 2010    | 2000     | 2010         | 2000    | 2010     | 2000          | 2010    |
| p50           | Mean ± SD   | p50     | Mean ± SD| p50           | Mean ± SD| p50      | Mean ± SD     |
| all BMI       | 16.21       | 16.85±2.56 | 16.52    | 17.1±2.59     | 16.47   | 16.97±2.53 | 16.49         | 17.04±2.59 |
| Frame-Index   | 40.38       | 40.49±2.36 | 40.24    | 39.71±3.49    | 38.95   | 39.09±2.42 | 38.86         | 38.46±3.16  |
| height        | 134.5       | 134.68±10.46 | 133.9    | 134.22±9.42   | 135     | 134.77±10.36 | 132.7         | 133.25±9.66 |
| 6 BMI         | 15.4        | 15.77±1.86 | 15.82    | 16.02±1.94    | 15.75   | 15.93±1.82 | 15.61         | 15.89±2.04  |
| Frame-Index   | 40.84       | 40.92±2.45 | 40.56    | 40.28±2.81    | 40.3    | 40.12±2.45 | 39.69         | 39.13±3.04  |
| height        | 123         | 123.02±5.49 | 123.8    | 123.7±5.79    | 122     | 121.47±5.53 | 121.2         | 121.5±5.68  |
| 7 BMI         | 15.87       | 16.29±1.98 | 15.81    | 16.21±2.17    | 15.85   | 16.33±2.47 | 15.93         | 16.39±2.21  |
| Frame-Index   | 40.75       | 40.96±2.23 | 40.61    | 40.11±3.47    | 39.1    | 39.12±2.55 | 39.1          | 38.75±3.06  |
| height        | 127.7       | 128±6.3   | 127      | 127.3±5.43    | 127     | 127.4±5.97 | 126.4         | 126.85±5.42 |
| 8 BMI         | 16.02       | 16.65±2.25 | 16.39    | 17.08±2.24    | 16.94   | 17.15±2.24 | 16.39         | 16.92±2.38  |
| Frame-Index   | 40.46       | 40.31±2.41 | 40.63    | 40.11±3.28    | 39.16   | 39.03±2.39 | 39.01         | 38.69±3.24  |
| height        | 134         | 134.1±6.13 | 133.2    | 133.15±6.14   | 134.2   | 134.33±6.32 | 131.8         | 132.19±6.05 |
| 9 BMI         | 16.6        | 17.4±2.77  | 16.88    | 17.76±2.79    | 16.73   | 17.3±2.77  | 17.03         | 17.49±2.84  |
| Frame-Index   | 40.37       | 40.41±2.45 | 39.94    | 39.18±3.89    | 38.47   | 38.73±2.26 | 38.4          | 38.01±3.15  |
| height        | 139.5       | 140±7.03  | 138.8    | 139.33±7.03   | 139.65  | 139.73±6.58 | 139.1         | 139.1±6.58  |
| 10 BMI        | 17.09       | 17.83±2.92 | 17.49    | 18.01±2.86    | 17.11   | 17.69±2.66 | 17.78         | 18.28±2.71  |
| Frame-Index   | 39.82       | 39.98±2.14 | 39.57    | 39.17±3.4     | 38.65   | 38.74±2.28 | 38.59         | 37.87±3.16  |
| height        | 144.5       | 144.93±7.02 | 144.1    | 143.47±6.72   | 144.5   | 144.75±6.78 | 143.1         | 143.68±6.83 |

Figure 2. Percentiles of the parameter Frame-Index for Russian and German girls for the years 2000 (dashed lines) and 2010 (solid lines).

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Test. Therefore to determine differences between the groups non-parametric test (Mann-Whitney-Test) was used. The following significance levels were used: $p < .001$ (**), $p < .01$ (*), $p < .05$ (*).

### Statistical analysis
Statistical analysis was realized by the program SPSS 19 IBM.

### Results

#### Russian children: Comparison 2000 and 2010
In Russian children the comparison between 2000 and 2010 showed that only BMI ($U = 109163$, $p < .001$) was distinguished but not height ($U = 130448$, $p = .222$) and Frame-Index ($U = 102801$, $p = .343$). The results were reflected in girls, only BMI ($p < .001$) was significantly higher in 2010 (BMI: $p50 = 16.47$ m$^2$/kg vs. Russian: $p50 = 15.99$ m$^2$/kg) but a lower Frame-Index ($p50 = 38.95$ vs. Russian: $p50 = 40.17$). In every age group a significant difference in Frame-Index can be found (Tables 2, 3, 4, Fig. 1).

#### German children: Comparison 2000 and 2010
In German children height ($U = 1734657$, $p < .001$), Frame-Index ($U = 1668006$, $p < .001$) and BMI ($U = 1749894$, $p < .009$) were significantly different in 2000 and 2010. German boys showed a higher BMI ($p < .002$) but a decreased Frame-Index ($p = .001$) especially at the 3rd and 10th (Fig. 1) percentiles in 2010. Height did not differ between the years in contrast to the German girls (2000: $p50 = 135$ cm vs. 2010: $p50 = 132.7$ cm; $p = .001$). In girls, BMI did not vary over the years ($p = .528$) but Frame-Index decreased like in boys and the same centiles (Tables 3, 4, Fig. 2).

| Table 5. Data comparison of the parameters BMI (kg/m$^2$), Frame-Index, height (cm) of Russian and German boys and girls per year 2000 and 2010. |
|---|---|---|---|---|
| **Russian vs. German** | **2000 boys** | **2000 girls** | **2010 boys** | **2010 girls** |
| **age parameter** | **U** | **p** | **U** | **p** | **U** | **p** | **U** | **p** |
| all BMI | 282725 | .630 | 217947 | $<.001^{***}$ | 59011 | .089 | 49013 | .292 |
| Frame-Index | 129504 | $<.001^{***}$ | 146007 | $<.001^{***}$ | 43494 | $<.001^{***}$ | 32166 | $<.001^{***}$ |
| height | 252018 | $<.001^{***}$ | 213033 | $<.001^{***}$ | 64407 | .953 | 47849 | .144 |
| 6 BMI | 3376 | .632 | 3180 | .599 | n.d.a | n.d.a | n.d.a | n.d.a |
| Frame-Index | 1873 | $.001^{**}$ | 2022 | $.005^{**}$ | n.d.a | n.d.a | n.d.a | n.d.a |
| height | 3125 | .265 | 2923 | .207 | n.d.a | n.d.a | n.d.a | n.d.a |
| 7 BMI | 10963 | .256 | 10153 | .905 | 4282 | .131 | 3546 | $.029^*$ |
| Frame-Index | 5786 | $.001^{**}$ | 5944 | $.001^{**}$ | 3603 | $.003^{**}$ | 2656 | $.001^{***}$ |
| height | 9769 | $.008^{**}$ | 9221 | .151 | 4473 | .275 | 3942 | .206 |
| 8 BMI | 12138 | .600 | 11274 | $.011^{**}$ | 2700 | .873 | 3019 | .409 |
| Frame-Index | 6226 | $.001^{**}$ | 8410 | $.002^{**}$ | 1818 | $.002^{**}$ | 2389 | $.010^{*}$ |
| height | 10976 | $.001^{**}$ | 11704 | $.004^{**}$ | 2347 | .173 | 2842 | .188 |
| 9 BMI | 17963 | .412 | 12562 | $.039^{*}$ | 3714 | .373 | 1809 | .166 |
| Frame-Index | 7601 | $.001^{**}$ | 8470 | $.001^{**}$ | 2845 | $.003^{**}$ | 1245 | $.011^{**}$ |
| height | 13906 | $.001^{**}$ | 11143 | $.001^{**}$ | 3592 | .236 | 1814 | .171 |
| 10 BMI | 7745 | .730 | 6150 | $.002^{**}$ | 2141 | .576 | 1395 | .733 |
| Frame-Index | 2788 | $.001^{***}$ | 3966 | $.001^{***}$ | 1254 | $.001^{***}$ | 826 | $.002^{**}$ |
| height | 5875 | $.001^{***}$ | 4566 | $.001^{***}$ | 1590 | $.010^{*}$ | 1405 | .771 |

U = Mann-Whitney-Test.
$p = p$-value, significant in bold.
significance levels $= p < .001$ (**), $p < .01$ (*), $p < .05$ (*).
n.d.a = no data available for Russian children.
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### Russian and German children in 2000
In 2000 between Russian and German children, BMI ($U = 998356$, $p = .001$), Frame-Index ($U = 569359$, $p < .001$) and height ($U = 925987$, $p < .001$) were significantly different. This result can be found in girls as well. German girls were taller (German: $p50 = 135$ cm vs. Russian: $p50 = 132.1$ cm), exhibited a higher BMI (German: $p50 = 16.47$ m$^2$/kg vs. Russian: $p50 = 15.99$ m$^2$/kg) but a lower Frame-Index (German: $p50 = 38.95$ vs. Russian: $p50 = 40.17$). In every age group a significant difference in Frame-Index can be found (Tables 2, 4, Fig. 2).

### Russian and German children in 2010
In contrast to the 2000 analysis in 2010 in children of both sexes a significant difference in Frame-Index was significantly different in every age group (Table 5). Russian boys (German: $p50 = 40.24$ vs. Russian: $p50 = 42.1$) but were smaller than German boys (German: $p50 = 134.5$ cm vs. Russian: $p50 = 132.7$ cm) in 2000. In 2010, BMI ($U = 216372$, $p = .043$) and Frame-Index ($U = 149073$, $p < .001$) were distinguished but not height ($U = 227552$, $p = .434$).
Discussion

It is established that the inclination of obesity and especially the increased body fat deposition is a result of genetic factors [23], [24]. Otherwise environmental factors as high-calorie nutrition, physical activity and sedentary behaviour affect body fat production as well. An imbalance of these components leads to overweight. This development can be found in different populations and has been evolved into a global problem [1]. Apart from this trend another new development can be shown in relation to the skeleton of the German children. The external skeletal robustness has decreased. Each element of the skeletal system as bone mass and density will be influenced by genetic factors. Furthermore environmental factors as calcium intake and physical activity affect on them [25], [26], [19]. This is likewise to the body fat deposition. Now we displayed a trend concerning to the skeletal system. Between two different populations (German/Russian) and within the population external skeletal robustness, BMI and height were compared. It was supposed that differences were existed between Russian and German data in 2000 and an approach in 2010. In 2010, BMI and height of the Russian children were adapted on the values of the German children while in 2000 differences existed. In Russian children BMI were increased due to the changed nutrition. More than a half of the calories were ingested in form of bread, pastries, sugar and potatoes [27]. Furthermore, the secular trend can be observed in Russian children especially in boys. Physical height increased in Russian children due to advance of socio-economic conditions [28]. Russian girls aged 10 were 3.5 cm higher on average in 2010 than in 2000. Unpublished data showed that sexual maturity began at the same age in 2010. In contrast German children were a little shorter in 2010 than in 2000. In German girls the differences between each age group vary in 2010 and 2000. This might be a sampling problem. Nevertheless, Scheffler (2011) showed the same results of decreased height. One explanation is that the environmental conditions are optimal and the genetic potential of body height has been achieved in industrialized countries [16]. In 2000 as well in 2010, Russian children exhibited a higher external skeletal robustness as compared with German children. This finding can be arising from genetic factors but also due to the dosage of physical activity. We assumed that physical activity is higher in Russian children than in German children. However, at present no data is available to consider that assumption. Though, Haste et al. [6] exhibited that Russian children were fitter than their contemporaries in the US. After all, in 2010 compared with 2000 in Russian boys’ external skeletal robustness were decreased whereas that negative development can be found in both sexes of the German children. Although the Russian children may be more physically active than the German children the development of a reduced physical activity may exist. In case of reduced physical activity in Russian children it affects boys at first. Environmental factors impact boys’ body composition stronger than girls [29]. Also according to one study Moscow girls are more physically active than boys [30].

Conclusions

In Russian boys both negative developments the increasing prevalence of obesity and the reduction of external skeletal robustness can be observed. In this context physical activity should be particularly investigated.

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Author Contributions

Conceived and designed the experiments: KR EG CS. Performed the experiments: KR EG CS. Analyzed the data: KR. Contributed reagents/materials/analysis tools: CS EG. Wrote the paper: KR.

References

1. Popkin BM, Adair LS, Ng SW (2012) Global nutrition transition and the pandemic of obesity in developing countries. Nutr Rev 70(1):3–21
2. Sudderick G, Vose C, McConnell D, Rayner P (2010) Ten year secular declines in the cardiorespiratory fitness of affluent English children are largely independent of changes in body mass index. Arch Dis Child 95:46–47
3. Sigmundová D, El Ansari W, Sigmund E, Frömöl K (2011) Secular trends: a ten-year comparison of the amount and type of physical activity and inactivity of random samples of adolescents in the Czech Republic. BMC Public Health 11:731
4. Jekauc D, Reimers AK, Wagner MO, Woll A (2012) Prevalence and socio-demographic correlates of the compliance with the physical activity guidelines in children and adolescents in Germany. BMC Public Health 12(1):714
5. Verloigne M, Van Lippevelde W, Maes L, Yldum M, Chinag DV, et al. (2012) Levels of physical activity and sedentary time among 10- to 12-year-old boys and girls across 5 European countries using accelerometers: an observational study within the ENERGY-project. Int J Behav Nutr Phys Act 9:34
6. Hastie P, Sinelnikov O, Wadsworth D (2010) Aerobic fitness status and out-of-school lifestyle of rural children in America and Russia. J Phys Act Health 7(2):150–160
7. Tudor-Locke C, Nell JJ, Ainsworth BE, Adly CL, Popkin BM (2002) Omission of active commuting to school and the prevalence of children’s health-related physical levels: the Russian Longitudinal Monitoring Study. Child Care Hlth Dev 28(6):507–512
8. McDonald N (2007) Active transportation to school - Trends among US schoolchildren, 1969-2001. Am J Prev Med 32(6):509–516
9. Bulin RN, Mitra R, Faulkner G (2009) Active school transportation in the Greater Toronto Area, Canada: An exploration of trends in space and time (1986–2006). Prev Med 48(6):507–512
10. Southward EF, Page AS, Wheeler BW, Cooper AR (2012) Contribution of the school journey to daily physical activity in children aged 11–12 years. Am J Prev Med. 43(2):201–4.
11. Basterfield L, Adamson AJ, Frary JK, Parkinson KN, Pearce MS, et al. (2011) Longitudinal Study of Physical Activity and Sedentary Behavior in Children. Pediatrics 127(1):e24–e30
12. Klimatskaya L, Laskiene S, Shpakou A (2011) Lifestyle and health behaviour of school aged children in Krasnoyarsk (Russia), Lithuania and Grodno (Belarus). Prog Health Sci 12(1):39–45
13. Lammlle L, Worth A, Bis K (2012) Socio-demographic correlates of physical activity and physical fitness in German children and adolescents. Eur J Public Health doi:10.1093/eurpub/ckr191
14. Rietsch K, Scheffler C (2011) Association between skeletal robustness and physical activity in schoolchildren – First results. Abstract Anthrop Anz 68(4):516
15. Rietsch K, Eccard J, Scheffler C (2013) Decreased external skeletal robustness due to reduced physical activity? Am J Hum Biol, in press
16. Scheffler C (2011) The change of skeletal robustness of 6–12 years old children due to reduced physical activity. Am J Hum Biol, in press
17. Morley RI, Bulin RN, McEwen JS, Ananeh-Firempong W (2010) Physical activity and bone mass: exercises in futility? Bone and Miner 50(2):11–12
18. Wolten DC, Kemper HCG, Post GB, Van Mechelen W, Twisk J, et al. (1994) Weight-bearing activity during youth is a more important factor for peak bone mass than calcium intake. J Bone Miner Res 9(7):1089–1096
19. Johnston CC, Miller JZ, Smendi CW, Reister TK, Hui S, et al. (1992) Calcium supplementation and increases in bone mineral density in children. N Engl J Med 327:82–87
20. Knutfinmann R (1988) Anthropologie: Handbuch der vergleichenden Biologie des Menschen; Band 1: Wesen und Methoden der Anthropologie. Stuttgart, Gustav-Fischer-Verlag
21. Frisancho AR (1990) Anthropometric standards for the assessment of growth and nutritional status. The University of Michigan Press, Ann Arbor
22. Pan H, Cole TJ (2011) LMSharmaker, a program to construct growth references using the LMS method. Version 2.54. Available: http://www.healthforallchildren.co.uk/
23. Stunkard AJ, Foch TT, Hrubez Z (1986) A Twin Study of Human Obesity. JAMA 256(1):31–34
24. Bouchard C, Perusse L, Leblanc C, Tremblay A, Thériault G (1988) Inheritance of the amount and distribution of human body fat. Int J Obes 12(5):205–15
25. Pollitzer WS, Anderson JJ (1989) Ethnic and genetic differences in bone mass: a review with a hereditary vs environmental perspective. Am J Clin Nutr 50(6):1244–1259
26. Slemenda CW, Miller JZ, Hui SL, Reister TK, Johnston Jr CC (1991) Role of Physical Activity in the Development of Skeletal Mass in Children. J Bone Miner Res 6(11):1227–1233
27. Kalinin A, Kolosnitshina M, Zastava L (2011) Healthy Lifestyles in Russia: Old issues and new policies. Series: Public Administration WP BRP 02/PA/2011
28. Godina E (2011) Secular trends in some Russian populations. Anthrop Anz J Biol Clinic. Anthrop 68(4):567–377
29. Schefler C, Schuler G (2009) Analysis of BMI of Preschool Children – Results of Longitudinal Studies. Anthrop. Anz 67(1):33–63
30. Pernyakova E, Godina E, Gilyarova O (2012) Vliyanie fyzicheskoi aktivnosti i sutochnogo potrebleniya kaloriyi na osobennosti zhivootlozheniya u sovremen-nykh detei i podrostkov Arkhangel’skogo regiona i goroda Moskvy [Influence of physical activity and daily calorie intake on fat development in modern children of Arkhangelsk region and Moscow], In Russian. Vestnik Moskovskogo Universiteta. Antropologiya 23(4):112–120