Size of Community and Motor Performance in Preschool Children

Wohnortgröße und motorische Leistungsfähigkeit von Kindergartenkindern

Problemstellung: Bewegung zählt zu den wichtigsten Faktoren, die bei der psychomotorischen Gesamtleistung von Kindern eine Rolle spielen. Immer mehr Kinder in Industriestaaten leiden aber an Bewegungsmangel und die motorische Leistungsfähigkeit im Kindesalter zeigt einen negativen Trend. Es stellt sich die Frage, ob es schon im Vorschulalter Unterschiede der motorischen Leistungsfähigkeit in Abhängigkeit von der Wohnortgröße gibt.

Methoden: Aus 24 Kindergärten in ländlichen Gemeinden (<5000 EW), 12 in klein- und mittelständischen Regionen (5000 bis 20.000 EW) und 5 in einer Großstadt (>100.000 EW), wurden insgesamt 1063 vier- und fünfjährige Kinder rekrutiert. Zur Erfassung der motorischen Leistungsfähigkeit wurde das Karlsruher Motorik-Screening (KMS 3-6) durchgeführt. Der BMI wurde durch Körpergröße und Gewicht ermittelt.

Ergebnisse: Die höchsten KMS-Scores wurden bei Kindern aus ländlichen Wohnorten erzielt (99,2 Scorepunkte gegenüber 97,0 Scorepunkten bei Kindern aus klein- und großstädtischen Wohnregionen). Unterschiede zwischen den Kindern der KMS 3-6 und denen der KMS 3-6 (p < 0,001). Es zeigten sich keine signifikanten Geschlechtsunterschiede (♀ 99,8 vs. ♂ 100,1; p > 0,4). Bei einer Ubergewichtsprävalenz von 13% im Gesamtkollektiv erzielten übergewichtige Kinder mit niedrigere Scores als normalgewichtige Kinder mit 97,2 (p < 0,001). Schlussfolgerung: In dieser Untersuchung zeigte die motorische Leistungsfähigkeit auch bei Kindergartenkindern in Bezug auf die Wohnortgröße teilweise signifikante Unterschiede. Es erscheint daher ratsam, vermehrt Bewegungsfördermaßnahmen in Kindergärten anzubieten und dabei insbesondere urbane Siedlungsflächen zu berücksichtigen.

Schlüsselwörter: Vorschule, sportmotorischer Test, Stadt-Landvergleich, körperliche Fitness

INTRODUCTION

The children’s world of movement has changed drastically during the last decades in western industrial nations and is characterised more and more by a reduction of daily physical activities and by a general lack of movement (3,6,21,29). Besides genetic factors, the children’s movement behaviour is mainly influenced by environmental factors (16). In this context, the residential environment plays a central role.

Differences in motor performance capabilities in relation to the population size of the place of residence have been the focus of several studies (5,7,10,12,20,29,31). In most of these studies, the place of residence has been differentiated by the size of the population using rural areas, small, medium and metropolitan communities as categories (24). Yet, these published studies show no consistent results.

Problem: Physical exercise plays a key role in the psychomotor development of young children. However particularly in developed countries an ever increasing number of children suffer from lack of exercise resulting in insufficient motoric capability. This current study on preschool kids explores a possible correlation between the size of their hometown and their motoric performance.

Method: A total of 1,063 four to five year old children were recruited from 41 kindergartens in Tyrol, Austria. 24 of these kindergartens were in rural communities (<5,000 inhabitants), 12 in small towns (5,000 to 20,000 inhabitants) and 5 in big cities (>100,000 inhabitants). Assessment tool for capturing the data was the Karlsruher Motorik-Screening (KMS 3-6).

Results: The highest KMS-scores were achieved by children in rural areas (99,2 score points; p < 0,01). Gender-related differences were not significant (♀ 99,8 vs. ♂ 100,1; p > 0,4). Differences between normal weight (100,4 score points) and overweight (97,2 score points) children however were significant (p < 0,001). Overweight/obesity was observed in 13% of the study population.

Conclusion: The study shows considerable varieties regarding motoric capabilities of kindergarten children with reference to the size of their hometown. It seems highly advisable to encourage and facilitate physical exercise in kindergartens particularly in urban settlements.

Key Words: preschool, motor-performance diagnostics, urban-rural relation, fitness

For example, Zimmer (31), Majerus (20) and Greier et al. (10) were able to prove a significant influence of the residential environment on the motor performance capabilities. They interpreted their results as a consequence of the reduction of areas suited for movement and physical activity caused by the increased population density and traffic. In contrast, Gaschler (7) and Joens-Marte et al. (12) found no relation between the motor performance capabilities and the size of the population.

Further, the results of the MOMO study conducted in Germany show that the motor performance capabilities of children and...
juveniles from rural and urban areas do not differ (29), but that children and juveniles from rural areas have a twice as high chance of being physically active outdoors at least four times a week (27).

Ketelhut et al. (15) have studied the effects of the social influences in urban settings on the motor performance capabilities and the activity levels in kindergarten-aged children. They report that children from urban and metropolitan areas have been deprived of adequate levels of areas suited for physical activity and movement by urban housing conditions and that active leisure time behaviour is often replaced by passive media consumption (15). Their study analysed the effects of social influences on the motor performance capabilities in the urban area of Berlin (Germany), but it did not analyse differences between urban and rural areas.

Most studies on the motor performance capabilities in relation to the size of the population have focused on elementary school children and juveniles, while kindergarten-aged children have rarely been analysed in this context. This is the objective of this study, in which a representative sample of Tyrolean kindergarten children has been analysed for influences of rural and urban living areas on the motor performance capabilities. It is important to already detect deficits in the development of motor performance capabilities in kindergarten age, since children can be influenced very early and no relevant pre-existing impairments exist at this young age (14).

Several different instruments and tools (4,25,30) provide ways for testing motor performance capabilities in pre-school children. One of the best-known tests for this is the motor test (Motoriktest) MOT 4-6 by Zimmer and Volkamer (30). The test includes 18 items and allows a classification of the general motor performance development. Conducting the tests takes a significant amount of time and is therefore hard to implement in large samples. A more time-economical alternative is the Karlsruhe motor screening (Karlsruher Motorik Screening – KMS 3-6) developed by Bös et al. (4). This test was created in order to be practical for kindergarten children and tests the aspects of motor performance capabilities of speed, strength, strength endurance, balance, coordination and flexibility. The decreasing physical fitness caused by a deficit in movement is often related to an increase in prevalence of overweight children (9,13,17). The influence of the body mass index (BMI) on motor performance capabilities has been studied extensively. Especially obesity goes in line with reduced motor performance capabilities (1,8,13). Further, differences in the prevalence of obesity in children and juveniles from urban and rural areas have also been well documented. These results are not consistent, though. Greier et al. (11) was able to detect higher levels of obesity in urban areas, while Joens Matre et al. (12) could not prove this in their study. That is why the BMI should be surveyed as a possible confounder in this study. Other possible confounders in this study are age and gender.

The central research question of this study was, whether there are already differences in the motor performance capabilities in kindergarten-aged children in relation to the size of the population of their place of residence.

**DATA AND METHOD**

In the federal state of Tyrol (Austria), around 18,000 children attended the 454 kindergartens in the school year 2011/12 (Tyrolean state government, department for education). Out of these, 77 are located in the outlying districts of Reutte and Lienz. These were not included in the study because of the high spatial distance. A random sample of 50 was chosen out of the remaining 377 kindergartens. The sample is representative for the relation between rural and urban areas in Tyrol, which is 4:3. The selected kindergartens were contacted and asked to participate in the study. Nine kindergartens were not able to participate because of organisational reasons. Accordingly, 41 kindergartens remained, from which 1,063 four to five year-olds were recruited (513 female and 550 male). The responsible carriers and the managing staff approved the study. The parents of the children were contacted by mail and asked for their approval as well.

The total number of four to five year-old children attending the selected 41 kindergartens in the school year 2011/12 was 1,082. Because of absence, for example caused by illness, two children were not surveyed in two metropolitan kindergartens, five children were not surveyed in kindergartens in small-size communities and twelve more children from eight rural kindergartens were not able to participate as well. Accordingly, 19 out of 1,082 children (1.7%) were not surveyed. This can be considered a representative sample for Tyrolean kindergarten children.

The acquisition of data about the size of the communities where the kindergartens are located was done using available data acquired in July 2011 by the Tyrolean state government (Raumordnungsstatistik). Four categories of residential areas_communities were differentiated in accordance to common criteria (24):

- Rural: less than 5,000 inhabitants
- Small city: between 5,000 and 20,000 inhabitants
- Medium city: between 20,000 and 100,000 inhabitants
- Urban/large city: more than 100,000 inhabitants

Since the state of Tyrol is for the most part rural with no medium cities and the state capital Innsbruck being the only city with more than 100,000 inhabitants (120,000), the three categories of “rural”, “small city” and “urban” were finally used.

The motor tests were conducted between October 2011 and May 2012 in the kindergartens during the regular opening hours.

First, the height and weight in sports clothes without shoes were determined. The measurement of the height was done using the mobile stadiometer „SECA” 213 (Seca GmbH &Co.Kg, Hamburg, Germany) with a precision of one millimetre and the body weight was measured using the calibrated scale „GRUNDIG” 3710 (Grundig AG, Nürnberg, Germany) with a precision of 0.1 kg. These one-time tests were conducted to the most part by the lead researcher and only to a small part by staff members, which were especially trained to use the testing equipment.

Based on these measurements, the BMI was calculated using the BMI reference system by Kromeyer-Hauschild et al. (18). According to this reference system, children are considered to be normal weight, if their weight is between the 10th and the 90th percentile. Children with values under the 10th percentile are considered underweight. If the weight is between the 90th and the 97th percentile, children are considered overweight and values over the 97th percentile are considered as obese. In order to evaluate the results, the BMI values were grouped in the two groups underweight/normal weight (W_low) and overweight/obese (W_high).

The management of the kindergartens provided the birthdates. Only four and five year-olds were included in the sample and
were grouped in the two age groups four years (≥4 to <5 years) and five years (≥5 to <6 years).

**Test Implementation**

The motor performance capabilities were measured using the Karlsruhe motor screening (KMS) for kindergarten children developed by Bös et al. (4). The children received an age-specific and thorough explanation of the tests. The children were allowed to get familiar with the equipment and the tests before the actual test began. According to the provided test descriptions, the children first did a rehearsal/test run of each test. The test battery consists of the four parts “stand and reach”, “one-legged stance”, “standing long jump” and “side-to-side jumps”.

**Stand and Reach (flexibility)**

This test serves the purpose of measuring the flexibility and mobility of the torso and the active stretching ability of the muscles in the rear of the trunk. During this test the upper body has to be lowered down as far as possible while keeping the legs straight. The distance between the fingers and the standing surface is measured. The standing surface is the zero point of the scale, values above the standing surface are negative, below are positive. The values are recorded in centimetres (cm).

**One-legged Stance (balance)**

This test measures the ability to balance while standing. The number of contacts with the floor during one minute of standing on one leg on a T-bar with eyes open is recorded. For more than 30 contacts the value 30 is recorded.

**Standing Long Jump (explosive strength)**

Using both legs, the child has to jump forward as far as possible. Two attempts are granted and the best distance is recorded. The child has to remain standing after the jump in order to make the jump valid.

**Side-to-Side Jumps (coordination under time pressure)**

This test serves the purpose of measuring total body coordination, action velocity and the strength endurance capability of the lower extremities. The child has to jump with both legs at a time from one side of a bar on the floor to the other as fast as possible for 15 seconds. The total number of successful jumps from two valid attempts are summed up and recorded.

**Data Analysis/Statistics**

For interval-scaled data, the statistical parameters mean (M) and standard deviation (SD) were used. Frequencies were presented in tables and diagrams. A sum score of all four tests was determined using a z-transformation (addition of all four z-values and dividing the sum by four). The values of the test item “one-legged stance” were multiplied by -1 in order to be comparable with the other three tests in which a high score indicates a good performance. The influence of the population size of the communities on this sum score was analysed using variance analysis while also considering the independent variables age, gender and BMI. A saturated type III model was constructed. The test for normal distribution of the sum score was done using the Kolmogorov-Smirnov test and the homogeneity of variances by Levene test.

**RESULTS**

Out of the analysed 41 kindergartens, 24 are located in rural areas, 12 in small cities and 5 in an urban area/large city.

The mean age of the analysed kindergarten children was 4.9 ±0.5 years and the mean BMI was 15.6 ±1.9. The standard deviation score (SDS) according to the Kromeyer-Hauschild et al. (18) calculation was 0.07+/−1.1 (M+/− SD). Hence, the children were on average at the 50th percentile with a standard deviation between

### Table 1: Anthropometric data of the 1,063 four- and five-year old Tyrolean kindergarten children, differentiated by population size

<table>
<thead>
<tr>
<th>Population Size</th>
<th>Anthropometric Data</th>
<th>N</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;5,000 inhabitants</td>
<td>Age (y)</td>
<td>606</td>
<td>4.9</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>Height (cm)</td>
<td>606</td>
<td>112.2</td>
<td>6.2</td>
</tr>
<tr>
<td></td>
<td>Weight (kg)</td>
<td>606</td>
<td>19.7</td>
<td>3.4</td>
</tr>
<tr>
<td></td>
<td>BMI (kg/m²)</td>
<td>606</td>
<td>15.6</td>
<td>1.8</td>
</tr>
<tr>
<td></td>
<td>SDS</td>
<td>606</td>
<td>0.0</td>
<td>1.0</td>
</tr>
<tr>
<td>5,000 – 20,000 infants</td>
<td>Age (y)</td>
<td>289</td>
<td>4.9</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>Height (cm)</td>
<td>289</td>
<td>111.3</td>
<td>5.6</td>
</tr>
<tr>
<td></td>
<td>Weight (kg)</td>
<td>289</td>
<td>19.6</td>
<td>3.3</td>
</tr>
<tr>
<td></td>
<td>BMI (kg/m²)</td>
<td>289</td>
<td>15.7</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>SDS</td>
<td>289</td>
<td>0.0</td>
<td>1.2</td>
</tr>
<tr>
<td>&gt;100,000 inhabitants</td>
<td>Age (y)</td>
<td>168</td>
<td>5.0</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>Height (cm)</td>
<td>168</td>
<td>112.7</td>
<td>6.6</td>
</tr>
<tr>
<td></td>
<td>Weight (kg)</td>
<td>168</td>
<td>20.9</td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>BMI (kg/m²)</td>
<td>168</td>
<td>16.3</td>
<td>2.2</td>
</tr>
<tr>
<td></td>
<td>SDS</td>
<td>168</td>
<td>0.4</td>
<td>1.0</td>
</tr>
<tr>
<td>total</td>
<td>Age (y)</td>
<td>1063</td>
<td>4.9</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>Height (cm)</td>
<td>1063</td>
<td>112.0</td>
<td>6.2</td>
</tr>
<tr>
<td></td>
<td>Weight (kg)</td>
<td>1063</td>
<td>19.9</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>BMI (kg/m²)</td>
<td>1063</td>
<td>15.8</td>
<td>1.9</td>
</tr>
<tr>
<td></td>
<td>SDS</td>
<td>1063</td>
<td>0.1</td>
<td>1.1</td>
</tr>
</tbody>
</table>

**Table 2: Frequencies of the analysed factor of population size differentiated by the potential confounders included in this study, gender, age and BMI group of 1,063 Tyrolean kindergarten children**

<table>
<thead>
<tr>
<th>Population Size</th>
<th>Kindergarten n (%)</th>
<th>Children n (%)</th>
<th>Gender n (%)</th>
<th>Age n (%)</th>
<th>BMI-Group n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;5,000 inhabitants</td>
<td>24 (59)</td>
<td>606 (57)</td>
<td>294 (49)</td>
<td>4.238 (39)</td>
<td>Wlow: 541 (89)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>M: 59.36 (61) Wlow: 65 (11)</td>
</tr>
<tr>
<td>5,000-20,000 inhabitants</td>
<td>12 (29)</td>
<td>289 (27)</td>
<td>141 (49)</td>
<td>4.114 (40)</td>
<td>Wlow: 247 (85)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>M: 59.175 (60) Wlow: 42 (15)</td>
</tr>
<tr>
<td>&gt;100,000 inhabitants</td>
<td>5 (12)</td>
<td>168 (16)</td>
<td>78 (47)</td>
<td>4.58 (35)</td>
<td>Wlow: 36 (81)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>M: 59.110 (65) Wlow: 32 (19)</td>
</tr>
<tr>
<td>total</td>
<td>41 (100)</td>
<td>1063 (100)</td>
<td>513 (48)</td>
<td>4.410 (39)</td>
<td>Wlow: 924 (87)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>M: 59.653 (61) Wlow: 139 (13)</td>
</tr>
</tbody>
</table>

Wlow: underweight/normal weight, Whigh: overweight/obese
Table 3: Mean values of the sum scores of motor performance capabilities of Tyrolean kindergarten children \( (n=1,063) \), differentiated by the population size and cleansed of the effect of age, gender and BMI (estimated residuals)

<table>
<thead>
<tr>
<th>Population Size</th>
<th>Mean Sum Score</th>
<th>95% CI</th>
<th>n</th>
<th>p</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;5,000 inhabitants</td>
<td>99.2</td>
<td>98.4 - 100</td>
<td>606</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5,000-20,000 inhabitants</td>
<td>97</td>
<td>96.1 - 98.0</td>
<td>289</td>
<td>0.005</td>
<td>5.4</td>
</tr>
<tr>
<td>&gt;100,000 inhabitants</td>
<td>98.5</td>
<td>97.2 - 99.8</td>
<td>168</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4: Uncleansed mean values and standard deviations of the sum scores for motor performance capabilities of Tyrolean kindergarten children \( (n=1,063) \) differentiated by age, gender and BMI.

The results are easy to compare to other results of KMS 3-6 tests not statistically significant \( (p>0.05) \).

The frequency distribution of age group and gender of the analysed 1,063 children was similar in all three population-size categories. The classification by BMI groups (underweight/normal vs. overweight/obese) did not show a consistent distribution in the three population-size categories. Almost twice as many overweight/obese children were recorded in the urban area/large city \( (19\%) \) compared to rural areas with only 11\% \( (Tab.\ 2) \).

The sum scores of the motor performance capabilities, differentiated between the three categories of population size, differ significantly after being cleansed from the effects of age, gender and BMI \( (p=0.005; Tab.\ 3) \). Multi-factorial analysis of variances did not show significant effects on the children's motor performance capabilities proven in previous studies \( (3,9,26,29) \). Using a multifactorial approach in this study, the effect of the residential environment was cleansed of these confounders. No influence of the gender on the sum score of the KMS 3-6 was detected. Bappert and Bös \( (2) \) were also able to show in their longitudinal study that the motor performance capabilities of preschool-aged girls and boys hardly differ.

The differences between rural and urban areas did not show as distinctly in Innsbruck, the only large city in Tyrol. Looking at the results of the individual test items, it showed that children from more rural areas with small towns \( (<5,000\) inhabitants) scored significantly higher in the two test items "one-legged stance" and "side-to-side jumps", compared to the group of children from smaller cities \( (5,000\ to \ 20,000\ inhabitants) \). In the test items "standing long jump" and "stand and reach" \( (Fig.\ 2) \) the children from rural areas scored only slightly higher than the children from small cities \( (p<0.05) \).

The differences between rural and urban areas did not show as distinctly in Innsbruck, the only large city in Tyrol. Looking at the results of the individual test items, it shows that the children from the large city scored significantly lower in the items "one-legged stance" and "standing long jump" compared to children from more rural areas while no significant differences were detected in the "side-to-side jumps". When testing for flexibility ("stand and reach"), the children from Innsbruck achieved higher scores than the children from other residential environments. Yet, these differences are not statistically significant \( (p>0.05) \).

In conclusion, the KMS 3-6 proved to be highly practicable. The results are easy to compare to other results of KMS 3-6 tests \( (4,10,15) \).
The size of the community already affected the motor performance capabilities of children in kindergarten age. The influence of the size of the community was significant in this study, yet the effect was not very distinct. The analysis of variances of the scores for motor performance capabilities shows that the variance in the sample can be explained by around 10% by the urban and rural residential area (partial $\eta^2 = 0.01$).

Under the assumption of a connection between physical activity, motor performance capabilities and the health status, a minimum amount of sports or physical activity per day is considered inevitable in order to provide for the health and wellbeing of children. In order to fulfil the daily requirements for total physical activity and movement, the WHO suggests that children should be physically active for at least 60 minutes a day at moderate to high intensities (28). However, national and international studies prove that around two thirds of all kindergarten children stay below these requirements (19,23).

Since the basis for an active lifestyle is laid in early childhood years and this basis positively affects the activity-related behaviour in the future stages of life, measures aiming at promoting physical activity should be increasingly offered in kindergartens, especially in areas where leisure time physical activity is hindered by a densification of the living environment. In this context Kettner et al. (16) point out that a cooperation with local sports clubs offers the opportunity to optimise these offers, especially in full-day kindergartens, in regard to the promotion of physical activity and the transfer of the sensation of joy and fun of being physically active.

**Limitations**

The socioeconomic status of the family also has an important influence on the motor performance capabilities (15,22). The residence in a wealthier or a less wealthy neighbourhood of a city has been used as a surrogate marker for the socioeconomic status. This was obviously not possible for this study. The acquisition of the socioeconomic status using more complex methods was not possible in this study for research-economical reasons, which constitutes a major limitation of this study. No reliable data on differences in rural and urban social structures in Tyrol is available at this time.

Beyond, other potential confounders were not considered. For example, full-day care is offered more often in urban kindergartens and schools, which may possibly further limit active forms of leisure time compared to rural areas. The leisure time activities (volume and intensity of physical activity) were not surveyed in this study.

**Conflict of interest**

The author has no conflicts of interest.

**Literature**


