Postural stability of children undergoing training in karate

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Abstract

Background & Study Aim: Physical activity develops motor skills. Muscular strength and suppleness development improve coordination ability. There are numerous reports on the beneficial impact of karate kyokushin on body posture and postural stability. It may be difficult to assess the effect of karate training on the postural stability of young schoolchildren, as body posture in children is naturally unstable and undergoes constant changes. The aim of the study was static balance in a group of karate training children and peers who did not train in martial arts.

Materials & Method: The study was conducted on 100 children. The study group consisted of 50 children who had been training karate for at least two years. There were 29 boys and 21 girls in the group. The control group consisted of 50 children of the same age. To achieve greater reliability of research, the clinical control group members were chosen on a 1:1 basis. The children from both groups did not differ significantly in terms of body mass, height or BMI, which allowed for a highly reliable comparison of the studied parameters.

Results: The compilation of the Mann-Whitney U-test results for the compared groups. The analysis of results revealed a statistically significant difference between the mean values of the MAML parameter (eyes open) and the MaxML parameter (eyes open) in measurements for the two groups of children. The analysis of results revealed a difference between the mean values of the LWML parameter – the number of sways on the x-axis (eyes open) in measurements for the two groups of children. Also the statistically significant differences has been observed between the mean values of the RQSA parameters (the Romberg quotient for the path length) and the mean RQSPA parameter values (the Romberg quotient for the COP field quotient with eyes open and with eyes closed) in measurements for the two groups of children.

Conclusions: Karate developed balance in children aged 7-10 years, in that it had a beneficial effect on their motor skills. Regular karate training developed increased medio-lateral postural stability and greater sensitivity of the postural system to the distorting stimuli. The dependence of postural stability on the corrective function of the visual system was lower in karate-training children due to the better-developed sensory integration.

Key words: comparatistic, karate kyokushin, martial arts, non-active children

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INTRODUCTION

Physical activity develops motor skills. Muscular strength and suppleness development improve coordination ability [1-4]. Eastern martial arts are a common form of recreation, and kyokushin karate is one of the most popular martial arts in Poland and around the world.

There are numerous reports on the beneficial impact of karate kyokushin on body posture and postural stability [5, 6]. The beneficial impact is related to the required correct starting position during training. Motor skills development, including coordination development, are the core of karate training, as they constitute the basis on which other abilities of karate contestants are formed, i.e. the combat techniques.

It may be difficult to assess the effect of karate training on the postural stability of young schoolchildren, as body posture in children is naturally unstable and undergoes constant changes. Many authors state that karate training develops motor skills in children to a lesser degree than in adults, and that this is probably related to the not yet stabilised postural stability of children [7-11].

No anthropometric reports on the impact of systematic karate training on body posture and postural stability in children have been found in the literature.

The aim of the study was static balance in a group of karate training children and peers who did not train in martial arts.

MATERIALS AND METHODS

After obtaining family consent and child assent to participate the study was conducted on 100 children. The study population (GROUP I) consisted of 50 children aged 7-10 years, with a mean age of 8.1±1.5 years. The children had been training karate for at least two years. There were 29 boys and 21 girls in the group. The control group (GROUP II) consisted of 50 children of the same age. The criteria for excluding children were: distinctive divergence from the norm in terms of development, and uncompensated postural disorders of distinctive intensity. Inclusion criteria met 68 children: 19 boys, and 15 girls from group I, 19 boys, and 15 girls from the control group. To achieve greater reliability of research, the control group members were chosen on a 1:1 basis, which means that, – for example, each 7-year old boy from the study population had a 7-year old boy counterpart in the control group. The children from both groups did not differ significantly in terms of body mass, height or BMI, which allowed for a highly reliable comparison of the studied parameters. The tests were conducted at the Kyokushin Karate Club in the Bielany, district of Warsaw (Poland). The karate practitioners trained there twice a week for 1.5 hours. The children from the control group were not involved in any physical activity on a regular basis.

The following balance parameters were analysed:

- SP – total length of COP path [mm]
- SPAP – length of COP path in the anterior-posterior plane, i.e., in the y-axis [mm]
- SPML – length of COP path in the medial-lateral plane, i.e., in the x-axis [mm]
- MA – mean amplitude of the COP projection [mm]
- MAAP – mean amplitude of COP projection in the anterior-posterior plane, i.e., in the y-axis [mm]
- MaxAP – maximal amplitude between the two most distant points in the anterior-posterior plane, i.e., in the y-axis [mm]
- MaxML – maximal amplitude between the two most distant points in the medial-lateral plane, i.e., in the x-axis [mm]
- MV – mean COP velocity [mm/s]
- MVAP – mean COP velocity in the anterior-posterior plane, i.e., in the y-axis [mm/s]
- MVML – mean COP velocity in the medial-lateral plane, i.e., in the x-axis [mm/s]
- SA – sway area marked by the moving COP [mm²]
- SPSA – quotient of total length of COP path to the sway area marked by moving COP path [mm/mm²].
- LWAP-EO – number of antero-posterior COP amplitudes.
- LWML-EO – number of medio-lateral COP amplitudes.
- MAML – mean amplitude of the COP projection in the anterior-posterior plane, i.e., in the y-axis [mm]
- MAAP – mean amplitude of COP projection in the anterior-posterior plane, i.e., in the y-axis [mm]
- MAV – mean COP velocity in the anterior-posterior plane, i.e., in the y-axis [mm/s]

RESULTS

The compilation of the Mann-Whitney U-test results for the compared groups is presented in table 1. Statistically significant differences were observed (p<0.05). Detailed analyses of the observed correlations are presented in figures 1-4.
Table 1. Compilation of the descriptive statistics of the analysed parameters, and of the Mann-Whitney U-test results for the parameters in the studied population (GROUP I) and the clinical control group (GROUP II).

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>GROUP I</th>
<th>GROUP II</th>
<th>U MANNA-WHITNEY'A</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>x̄</td>
<td>Me</td>
<td>Min.</td>
</tr>
<tr>
<td>SP-EQ [mm]</td>
<td>336.9</td>
<td>323.0</td>
<td>171.0</td>
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<tr>
<td>SPAP-EQ [mm]</td>
<td>220.4</td>
<td>206.5</td>
<td>114.0</td>
</tr>
<tr>
<td>SPML-EQ [mm]</td>
<td>203.5</td>
<td>202.5</td>
<td>92.0</td>
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<tr>
<td>MA-EQ (mm)</td>
<td>3.4</td>
<td>2.8</td>
<td>1.0</td>
</tr>
<tr>
<td>MAAP-EQ (mm)</td>
<td>2.6</td>
<td>2.4</td>
<td>0.8</td>
</tr>
<tr>
<td>MAML-EQ [mm]</td>
<td>1.5</td>
<td>0.9</td>
<td>0.4</td>
</tr>
<tr>
<td>MaxAP-EQ [mm]</td>
<td>10.2</td>
<td>7.5</td>
<td>2.3</td>
</tr>
<tr>
<td>MaxML-EQ [mm]</td>
<td>6.9</td>
<td>3.6</td>
<td>1.6</td>
</tr>
<tr>
<td>MV-EQ [mm/s]</td>
<td>11.2</td>
<td>10.8</td>
<td>5.7</td>
</tr>
<tr>
<td>MVAP-EQ [mm/s]</td>
<td>7.3</td>
<td>6.9</td>
<td>3.8</td>
</tr>
<tr>
<td>MVML-EQ [mm/s]</td>
<td>6.8</td>
<td>6.8</td>
<td>3.1</td>
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<tr>
<td>SA-EQ [mm^2]</td>
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<td>243.0</td>
<td>63.0</td>
</tr>
<tr>
<td>LWAP-EQ</td>
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<td>15.5</td>
<td>3.0</td>
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<tr>
<td>LWML-EQ</td>
<td>24.9</td>
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<td>3.0</td>
</tr>
<tr>
<td>MNDB-EQ</td>
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<td>2.0</td>
<td>−14.0</td>
</tr>
<tr>
<td>ROSP</td>
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<td>1.1</td>
<td>0.0</td>
</tr>
<tr>
<td>RQSA</td>
<td>1.5</td>
<td>1.4</td>
<td>0.0</td>
</tr>
<tr>
<td>RQMV</td>
<td>1.1</td>
<td>1.1</td>
<td>0.0</td>
</tr>
<tr>
<td>RQSMA</td>
<td>1.0</td>
<td>0.9</td>
<td>0.0</td>
</tr>
</tbody>
</table>

The analysis of results revealed a statistically significant difference (p=0.0103) between the mean values of the MAML parameter (eyes open) in measurements for the two groups of children. The graphical representation is a figure showing the distribution of results in both groups. It is important to note the curve vertex shift – it can be seen that the red vertex is shifted further than the blue vertex. Children from the control group had higher mean results for the centre of foot pressure amplitude on the x-axis.

There was a statistically significant difference (p=0.0095) between the mean values of the MaxML parameter (eyes open) in measurements for the two groups of children. The figure depicts the distribution of results in both groups. The curve vertex shift shows that the higher mean results for the maximal amplitude of centre of foot pressure on the x-axis were found in the control group children.

The analysis of results revealed a difference (p=0.0251) between the mean values of the LWML parameter – the number of sways on the x-axis (eyes open) in measurements for the two groups of children. A curve vertex shift was noted – the blue vertex was shifted further than the red vertex. The karate-training children had higher mean results, which means they had a mean of more sways.

The figure shows the statistically significant differences (p=0.0100) between the mean values of the RQSA parameters (the Romberg quotient for the path length) in measurements for the two groups of children. The curve vertex shift is worthy of note – the blue vertex was shifted further than the red vertex. The karate-training children had higher mean results.

Statistically significant differences (p=0.0072) were found between the mean RQSMA parameter values (the Romberg quotient for the COP field quotient with eyes open and with eyes closed) in measurements for the two groups of children. The figure analysis reveals a curve vertex shift – the red vertex is shifted further than the blue vertex. The control group children had higher results.
Figure 1. Value distribution of the parameter denoting the mean amplitude of the centre of foot pressure in the medio-lateral plane – on the x-axis (MAML-EO).

**GROUP: I**  
MAML-EO [mm]:  
- \( N = 34; \) mean = 1.4794; sd. = 1.8627; Max = 9.5; Min = 0.4

**GROUP: II**  
MAML-EO [mm]:  
- \( N = 34; \) mean = 2.4471; sd. = 2.9488; Max = 15.7; Min = 0.3

Figure 2. Value distribution of the parameter denoting the maximal amplitude of the centre of foot pressure projection from the O point, in the medio-lateral plane – on the x-axis (MaxML-EO).

**GROUP: I**  
MaxML-EO [mm]:  
- \( N = 34; \) mean = 6.8794; sd. = 11.6386; Max = 70.1; Min = 1.6

**GROUP: II**  
MaxML-EO [mm]:  
- \( N = 34; \) mean = 16.9; sd. = 31.5708; Max = 139.3; Min = 1.7
The analysis of results revealed a statistically significant difference (p=0.0103) between the mean values of the MAML parameter (eyes open) in measurements for the two groups of children. The graphical representation is a figure showing the distribution of results in both groups. It is important to note the curve vertex shift — it can be seen that the red vertex is shifted further than the blue vertex. Children from the clinical control group had higher mean results for the centre of foot pressure amplitude on the x-axis.

There was a statistically significant difference (p=0.0095) between the mean values of the MaxML parameter (eyes open) in measurements for the two groups of children. The figure depicts the distribution of results in both groups. The curve vertex shift shows that the higher mean results for the maximal amplitude of centre of foot pressure on the x-axis were found in the clinical control group children.

The analysis of results revealed a difference (p=0.0251) between the mean values of the LWML parameter—the number of sways on the x-axis (eyes open) in measurements for the two groups of children. A curve vertex shift was noted — the blue vertex was shifted further than the red vertex.

Figure 3. Value distribution of the parameter denoting the number of centre of foot pressure amplitudes in the medio-lateral plane – on the x-axis (LWML-EO)

Figure 4. Value distribution of the parameter denoting the Romberg quotient for the COP field (RQSA)
**Discussion**

The conducted study revealed the effect of karate training on postural stability. The studied population of children was characterised by a considerable natural postural instability related to the young age and development [8-10]. However, the studied population had better static balance test results than the control group.

Numerous authors have observed the effect of various sports disciplines on the motor skills and balance control [12-15]. Karate training develops strength, endurance and coordination, which in turn improve the balance system [5,13,16-17]. Regular training improves sensomotoric organisation [18-20] and enhances reaction speed [20]. It helps improve motor ability test results, including balance control [12, 18, 21].

In their study, Conant et al. pointed out that regular karate training had a beneficial effect on the quality of life of epileptic children. This stems from the multidimensional impact of karate on a young system [22]. The increase of the muscular strength of lower limbs [13-14] has a beneficial effect on the ability to keep balance.

In their study, Fonga et al. noted an improvement of balance reactions quality in comparison to control group [13, 23]. Our study confirmed this findings.

Other studies proved the effect of doing sports on the changes in spinal curvature and spinal symmetry [24-26]. This is achieved through the required starting position assumed during training. Our own studies prove that such changes have an impact on postural stability, they stimulate the initial muscle tone responsible for the time and quality of the proprioceptive sensation reception, and stimulate muscle reply to the sensory input [27-31].

In the studied population, in comparison to the control group, an increased medio-lateral stability was observed. Lower values were observed for the parameters of the mean COP amplitude on the x-axis and the maximal amplitude from the reference point for this direction. However, the number of the COP amplitudes for this direction increased. It was related to the correction signal and clearly points to the increased reactivity of the postural system controlled by the balance system, which proves the enhanced readiness to counteract the balance-disturbing stimuli [32-33]. These reactions become part of the phenomenon of postural stability as discussed by numerous authors, including Błaszczyk [34,36]. Postural stability is the ability of the postural system to regain the relative balance after an action from a balance-disturbing stimulus [36-38].

In the quantification of static balance in the studied population, 30-second measurements with eyes closed were taken. After comparing the results (the measurement with eyes open and the measurement with eyes closed), the Romberg quotient was determined. The quotient is calculated by the equipment, and relates to the values of the measured parameters with eyes open and eyes closed. On the basis of the quotient, one can determine the degree of dependence of postural stability on the visual system [39,40]. In the cases of the parameters of field COP, COP path length or COP velocity (a function of time represented in the stabilograms), the lower the value of the quotient, the more the quality of the balance reaction is dependent on visual control. The control has the value of correction and it allows for the finding of an external frame of reference [41]. It may also point at the considerable disorder of the functions of the proprioceptors of joints and muscles, or disorders unrelated to the cerebellum, for example dorsal column-medial lemniscus tract disorders [42-43]. Such dysfunctions affect the quality of the balance system response to a much greater degree in measurements with eyes open. The diagnosis of considerable proprioceptive sense disorders can be made when the Romberg quotient value does not rise considerably for a generally bad result (considerable values of path length etc). A similar situation arises when the patient suffers from visual disorders (the visual system does not compensate for the information deficit from the proprioceptors). On the other hand, the correlation of the Romberg quotient for the COP path length and COP field quotient is different. The result of the (mathematical) quotient itself has to be interpreted in the following way: the greater the value, the greater the postural stability. The Romberg quotient for the mathematical quotient, however, has to be interpreted otherwise: the lower the value, the lower the dependence of the postural stability on the visual system.

We found that in the karate-training children posture was less dependent from the corrective signal from the visual system than in the control group [44-45]. This may prove that the balance reaction quality intensified in the studied population, resulting from strong sensomotoric integration [20, 23, 46-47], and the following increase in balance system readiness and an enhanced sense of one’s own body in space [41].
Our observations may be used in the therapy and training of people with motor and balance disorders. Through carefully chosen forms of karate training, subjects with a narrowed safety margin may develop their coordination skills in an attractive way. Karate should be treated as a supplementary form of balance training for fit subjects, including children. Karate influences balance indirectly, in that it develops motor skills and coordination.

**CONCLUSIONS**

Karate developed balance in children aged 7-10 years, in that it had a beneficial effect on their motor skills. Regular karate training developed increased mediolateral postural stability and greater sensitivity of the postural system to the distorting stimuli. The dependence of postural stability on the corrective function of the visual system was lower in karate-training children due to the better-developed sensory integration.

**COMPETING INTERESTS**

The authors declare that they have no competing interests.

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