The use of biomechanics in the methodology of teaching aikido to children

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B Data Collection
C Statistical Analysis
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Abstract

Background: and Study Aim: This study's purpose was to test the effectiveness of various methods of teaching aikido to children. Another goal was to see how the knowledge of biomechanics with regard to the principles of mechanics used in aikido techniques affects their execution.

Material/Methods: The research involved a population of fourth-form pupils aged 10–11, divided into two 25-strong training groups ('A' and 'B'), who practised aikido at extra-curricular PE classes. Group A were taught using the 'general-to-specific' method, with the prevalence of the synthetic method. The explanation of the execution of aikido techniques relied on the principles of biomechanics. Group B were taught using the 'specific-to-general' method, with the analytical approach prevailing. After a month's practice both groups were tested for their performance. Additionally, Group A were asked questions to make sure that they understood the principles of mechanics applied to the execution of the techniques.

Results: On average, the children in Group A got higher scores for the execution of aikido techniques, compared with their counterparts in Group B. High correlation was found between the scores and the answers to the questions about the biomechanics of aikido techniques.

Conclusions: The children taught aikido using the 'general-to-specific' method mastered the techniques better than the children taught the analytical way. The application of the theoretical explanation of mechanics principles at work in aikido improves the execution of the techniques. Teaching aikido to children allows one to familiarise them with the laws of mechanics, i.e. the forces acting on a person while in translatory or rotary motion.

Key words: aikido • biomechanics • teaching methodology • martial arts

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Background

Martial arts – fighting techniques, sometimes involving use of mêlée weapons. All martial arts are focused on training which teaches one self-defence, aggression and emotions control, and improves fitness. In contrast with combat sports, martial arts involve also spiritual and cultural development (traditional values).

The involvement of children in **martial arts** and combat sports is a fairly common phenomenon nowadays. The course instructor's responsibility is to act as a role model for the youngsters – both physically and mentally. It is generally acknowledged that martial arts train both the body and the mind. According to Harasymowicz and Kalina, [1] any kind of self-defence is a result of the work of the rational mind which perceives or predicts dangers, immediately assesses the ways and odds of a successful counteraction, and controls its own motor reaction, adjusting it to the behaviour of the opponent and other circumstances. According to Jaskólski, martial arts deserve detailed research, especially with regard to the way they could be used in education [2].

In this author's opinion, it is possible to use **aikido** not only for educational purposes, including physical education [3–5], but also to make children understand the laws of physics governing man's mechanical motion. This paper is part of this author's research into the effects of the use of the knowledge of **biomechanics** upon teaching sports and martial arts techniques.

Biomechanics – scientific study of mechanical properties of tissues and organs and of living organisms' locomotion and its causes and results with regard to laws of mechanics.

Aikido – martial art of a decidedly defensive character, involving mainly throws and joint locks to neutralise the attacker. Under the rules laid down by aikido's founder, the defence must not result in injury to the attacker. The Japanese 'ai-ki-do' is translated as a 'way to harmonise man's inner spiritual energy.' In many masters' view, aikido's purpose is to harmonise the development of body and mind.

Teaching methodology – study of the ways of managing pupils' work. It is divided into general and specific methodologies.

The research first focused on shot put and aikido and involved secondary school students [6,7]. This paper presents the research on primary school pupils, aimed at finding out about the results of using different methods of teaching aikido to children. Detail goal was to see how the knowledge of biomechanics with regard to the principles of mechanics used in aikido techniques affects their execution.

Material and Method

Subjects

The research involved fourth-form pupils at a primary school in the town of Koło, Poland, aged 10–11, divided into two 25-strong training groups (A and B). The pupils were selected at random. The two groups thus formed were representative enough for the whole of the school's pupil population. The pupils at the school came from one district, so the groups were homogenous because pupils' qualification to separate groups was base on random selection practiced since years (selection does not considered special skills, intelligence, material or social status, achievements of previous education years etc).

Experiment

The experiment was performed during the first term of the school year of 2001/2002. The research methodology paralleled the one this author used to teach aikido to secondary-school students [7]. The subjects practised aikido at extra-curricular PE classes. Having mastered safe falling – necessary for the practice of aikido, the pupils were taught four aikido techniques over a period of one month. The selected aikido techniques utilised *hikiotosu* throws which involve pulling the opponent downwards [8]. Such throws are used in sumo, judo, and aikido. Very often the execution of such techniques involves moving along a curve and lowering one's centre of gravity in order to employ the centrifugal force acting on the opponent and one's own gravity. In the experiment the children were taught the techniques of *kokyu nage* throw. Two techniques followed *katatedori ryotemochi* attack, one followed *yokomen uchi*, and one – *ryokatadori* attack. The instructor showed such a way of their execution that allowed for taking maximum advantage of the centrifugal force acting on the attacker as well as the weight of the defender.

Group A were taught using the 'general-to-specific' method [3], whereas Group B were taught using the 'specific-to-general' method, with the analytical approach prevailing. Successive movements of a particular technique were taught. Only after the children mastered the particular movements, were they taught to put them together in order to perform a particular technique. The children learnt the movements by following closely the instructor's movements. Group A were taught using the 'general-to-specific' method, with the prevalence of the synthetic method: for instance, **teaching** a particular technique's proper movements involved decoding the motor abilities the children already possessed.

A good idea is, for instance, to enact "crowded underground station" [3]: the trainees occupy a small space in a room thus making artificial crowd. At a signal they start moving fast. It can be seen that some of them, in order to avoid a collision with others, in a natural way make turns and revolutions. It may happen that they have already mastered the proper way of turning and revolving – and they only need to retrieve it. During the instruction, the instructor first tried to find out which turns and revolutions the children had already mastered. Next he showed how to use them in a particular aikido technique. Only the lacking abilities were taught from scratch.

Group A was taught aikido, drawing on the knowledge of biomechanics [9] which was a completely new thing to the children since physics is not included in the primary-school curriculum. The techniques were explained by, for example, quoting the second principle of dynamics of rotary motion, the principle of conservation of angular momentum or the factors influencing the value of the centrifugal force. Because the children at this age have no mathematical knowledge that would allow them to understand the principles in the form of formulae, the particular laws of physics were taught by means of experiment presentations, without the use of scientific terminology. Instead, children's language was the one of instruction. The presentations included observing a top spinning. The children played 'top fights' on special boards, by making the tops move in such a way that they crashed into each other. The children were then informed that the top's motion is imitated in some aikido techniques. However, they were also made aware that those techniques also involve vertical motion – resembling a top which suddenly rises or lowers its position while spinning. The children were told that this additional vertical motion was the one which allows an aikido practitioner to take advantage of his mass while performing a defensive technique. Next the children were shown a sample technique involving this kind of motion. The children were also allowed to try and execute the technique – imitating the movements of a top. Referring to biomechanics, the instructor explained aikido teaching principles [3,6,9], such as 'turn around if you are being pushed', 'go if you are being pulled', or 'give in to win'.

After the explanation of the principles of mechanics on the basis of aikido techniques, Group A children

were tested for their understanding. By asking questions and using questionnaires, the children's understanding of the movements in aikido techniques was assessed. A sample question went: 'Using the knowledge of biomechanics, how to move a particular body part in order to execute a particular aikido technique most effectively?'

After the questionnaire-based oral testing in Group A, both groups were taught four aikido techniques This research method was also used by this author when carrying out research on secondary-school students [7]. After a month's time, the children were tested for their execution of the techniques. The assessment focused on the effectiveness of execution of a particular sequence of movements, regardless of the tempo which was to be slowed down. The tempo of the attacker was adjusted so that the defender could execute all the successive movements of a particular technique within optimum time with regard to the individual abilities of the children. The correctness of the execution was assessed by this author using 1-10-point score scale, so the maximum score was 40 points.

To analyse the findings mathematical statistics methods were used, including analysis of regression and t-Student test for the independent variables. Analysis of regression was used to find out about the correlation between the correctness of answers to questions concerning biomechanics and the correctness of aikido techniques' execution. The relation between the scores for the execution of aikido techniques and the type of group was examined using t-Student test for the independent variables.

Results

Ascertained statistically significant difference ($p<0.05$) between the arithmetic mean of the results of students educated by different methods. More effective turned out the 'general-to-specific' method used by the group A (Figure 1).

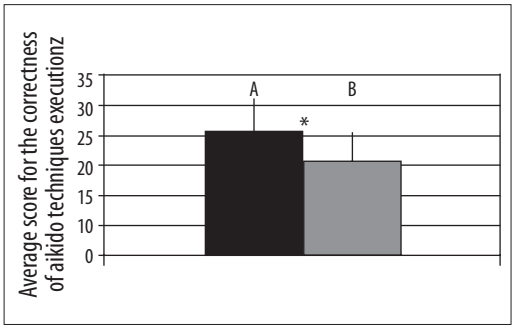

Figure 1. Average scores of children in both groups (A and B) for the execution of aikido techniques (*p<0.05).

The high statistical significant correlation coefficient ($r=0.75$ for $p<0.001$) was found between the correctness of the answers to questions concerning biomechanics and the correctness of the execution of aikido techniques (Figure 2).

Discussion

The high correlation between the correctness of the answers to questions concerning biomechanics and the scores for the correctness of the execution of aikido techniques is consistent with this author's previous research's findings: similar correlation was found to occur in the case of secondary-school students [6,7] – high correlation was found between the shot put results and correctness of aikido techniques execution and the understanding of biomechanics of those sports. The experiment referred to in this paper differs from the previous study in the way the knowledge of biomechanics was conveyed. The previous study made use of the mathematical formulae describing the principles of mechanics which the students had come to know at physics classes. With 10–11-year-old pupils only experiment presentation was possible to illustrate the principles of mechanics employed by aikido techniques. In his earlier research, this author was able to test the pupils' understanding of the laws of mechanics in particular groups at the beginning of the experiment. This was all but impossible

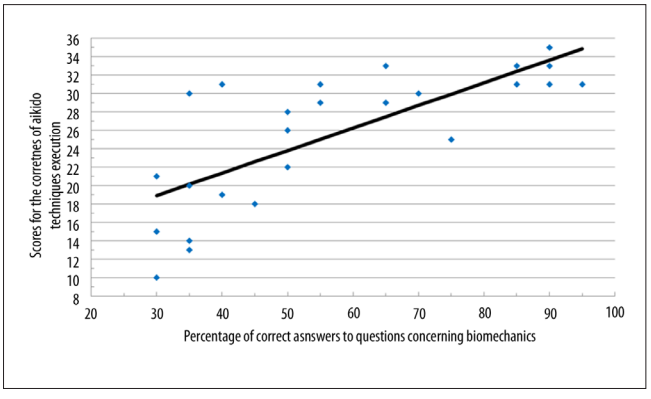

Figure 2. Correlation between the scores for the execution of aikido techniques and the correctness of answers to questions on biomechanics in Group A (n=25). Simple regression equation: $y=11.538+0.245x$, $r=0.75$.

Specific judo terminology (in Japanese):

kokyu nage – a throw without joint locks, with proper breathing, executed without stopping the attacker but with possible change in the attacker's movement.

ryokatadori – both-hands grab at the clothing on the chest.

katatedori ryotemochi – both-hands grab at one wrist.

yokomen uchi – diagonal knifehand strike to the side of the head or neck.

in the present research, since the pupils had not had physics at school yet.

Sports instructors and PE teachers may have problems requiring their charges to apply mathematical approach to the interpretation of the principles of mechanics. This may be due to a lack of the required knowledge which they ought to have possessed at school or their being loath to refer to physics and its formulae. There is, however, a way of drawing upon the knowledge of biomechanics in the methodology of teaching sports: it can be conveyed through experiments and presentations – as has been done by this author with regard to teaching aikido.

The results show that the aikido techniques were mastered best by those who were better at understanding the principles of mechanics involved in the techniques, from which it follows that it is justified to explain the way of performing a particular technique quoting biomechanics. The concept of motor teaching which relies on the awareness and understanding of the task while learning a specific move, proposed by Bober and Zawadzki [10], appears to be a valid one, too, with regard to the teaching of aikido to children. Such a teaching method not only facilitates the repetition of already mastered moves, but also helps invent new ones according to the needs.

The aikido classes employing the 'general-to-specific' method resulted in a better mastering of aikido techniques than the ones based on the 'specific-to-general' method – as is confirmed by Group A's higher average score for the execution of aikido techniques, compared with Group B (Figure 1). Thus, the synthetic way of teaching the execution of the techniques gave better results than the analytic teaching of successive moves involved in a particular technique. With Group A, an experimental interpretation of the laws of mechanics, describing rotary and translatory motion of man's body, was used. In this case the interpretation relied mainly on using the partner to explain the laws of physics governing translatory and rotary motion. Performing a particular aikido technique with a partner gives one an opportunity to feel the effects of the force exerted on the partner and vice versa. Such a possibility to experiment has been noted by Kalina [11]. According to him, what A aikido student experiences from B aikido student, will in a moment be B's experience due to A. Such participation in mechanical motion may help one understand mechanics – in compliance with a pedagogical permanence principle of 'stimulating the most of a learner's senses' [7]. The instruction based on the use of the knowledge of physics in martial arts may not only be used with techniques, but also to teach safe falling. Simple experiments with a notebook or a cushion falling may explain the principles of safe falls in judo or aikido – by showing how falls' mechanical energy can be reduced by increasing the body surface that hits the ground [12–15]. A show experiment may improve the child's understanding of the importance of positioning oneself properly while falling.

Naturally, only biomechanical knowledge is not enough to execute correctly an aikido technique – at high speed and with optimum dynamics. A necessary requirement is the student's proper development of motor abilities. According to Starosta and Rynkiewicz [16], the ultimate success in a fight also depends on the ability to 'feel the opponent'. The method adopted for the needs of this experiment did not require the children to display motor abilities at certain level because of the form of instruction, a presentation of the execution of techniques. This researcher's assessment method applied to a slowed-down execution of aikido techniques, which was necessitated by the need to limit the effect of the subjects' motor fitness upon the effectiveness of execution. Besides, in the process of movement management slow movements allow the so-called "feedback" whose presence can be detected not only after the execution of a movement but also during the execution [10,17,18]. This allows for managing movements during execution.

Practising self-defence develops psychomotor abilities [1]. The basic psychomotor ability which depends on the knowledge of biomechanics is the ability to choose a proper way of defence. Many authors explain the dynamics of the defence techniques quoting principles of biomechanics [9,19–21]. Of special interest here are Jigoro Kano's lectures explicating the 'give in to win' principle [22]. The father of judo was familiar with the biomechanical aspect of judo.

The interplay of centrifugal and centripetal forces or movements resembling spinning top, involved in the execution of aikido techniques, was understood by the son of aikido's founder, Kishomaru Ueshiba [23]. According to Koichi Tohei, the creator of aikido had mastered the art of relaxation in the execution of the techniques [24] – which is connected with the proper use of one's own body mass while throwing the opponent [9]. Other authors also stress the effect of the principles of mechanics in the execution of aikido techniques [7,25].

Selected aikido exercises may offer health benefits, especially as prevention against faulty posture in children [4,26]. This study has shown that while teaching aikido techniques, one can teach children the understanding of the laws of physics describing rotary and translatory motion. Children may learn to predict the results of sudden changes of the direction of their movement,

e.g. turning suddenly while running straight. In this way they may learn about the forces involved in such changes and about ways of using those forces for a particular purpose. This experiment's results point to the martial arts' capacity to develop not only motor efficiency in children but also their cognitive abilities

In view of the above, the belief that martial arts can develop both body and mind seems justified. This author supports Prof. E. Jaskólski's suggestion to carry out more detailed research into the way martial arts could be used in man's education. Unfortunately, there is a tendency at the moment for some of the martial arts to develop sports-wise, thus becoming ever more offensive rather than defensive [11,27,28]. Extreme offensiveness may border on aggression, which may result in abortion of judo philosophy and make martial arts less useful for pedagogical purposes.

Conclusions

1. The children taught aikido using the 'general-to-specific' method mastered the techniques better than the children taught the analytical way.

2. The application of the theoretical explanation of mechanics principles at work in aikido improves the execution of the techniques.

3. Teaching aikido to children allows one to familiarise them with the laws of mechanics, i.e. the forces acting on a person while in translatory or rotary motion.

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