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Teaching selected aikido techniques with the use of a rotating training simulator

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
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Abstract

Background & Study Aim: Aikido belongs to martial arts with an exceptionally defensive character (the key to performing many aikido techniques is the proper use of the offender's force). The force that causes the attacker to fall down is the net force of the centrifugal force affecting him and the force connected mainly with the defender's body weight. A rotating training simulator is the device equipped with a special movable platform with handles that can be held with hands, and can be used to check the influence of positioning of body segments during the rotational movement, on achieving the centrifugal force. The aim of the research was to answer the questions: a) whether way the kind of manner of conducting aikido class can influence the efficiency of mastering aikido techniques; b) in what way biomechanical knowledge on the mechanics principles applied in aikido techniques, can impact the correctness of performance.

Material & Methods: The research included a 51-person group of students of physical education at stationary college, aged 22 to 26 years old. The students participated in aikido classes during their regular curriculum. They were randomly divided to group A (n = 24) students who additionally practiced on a rotational training B (n = 27) students who learned aikido techniques only in a traditional fashion (based on performing a particular technique by imitating the coach's movements). In group A, performing aikido techniques were explained using biomechanical knowledge. As soon as the students learned the way of safe falling necessary to practice aikido techniques, they were taught for the period of one month, four different aikido techniques. In these techniques the defender, using the dynamics of a rotational movement, neutralized the attack with a throw. The precision of performing each aikido technique was evaluated by means of a 10 point scale (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 student. The students in group A were asked to write a test to evaluate their understanding of the mechanics of rotational movement.

Results: For the performance, group A scored much higher average value in comparison to group B ($p<0.05$). A relevant correlation was observed between answering the question correctly in the subject of biomechanics and the precision of performing aikido techniques ($r = 0.74$).

Conclusions: Using the rotational training simulator enabled quicker learning of aikido techniques. The students who understood better the mechanics of a rotational movement, also did better in performing the techniques. The aspect of that knowledge may have more meaning in the future, though (PEteachers should understand precisely the principles of mechanics which describe rotational movement; they are responsible for the motor safety of students during e.g., doing gymnastic exercises with high-dynamic rotational movements – an improper movement can cause an unfortunate fall while performing the exercise).

Key words: biomechanical phenomena • Jigorō Kano • martial arts • motor safety • rotational movement

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INTRODUCTION

Aikido is an especially defensive martial art. The scientific description of its biomechanics [1] explains that most aikido techniques rely on the clever use of the attacker's force. The defender can do so by turning that force into rotation. As a result, the force causing the attacker to fall is a combination of the centrifugal force acting on the attacker and the force originating in the weight of the defender. The skilful use of centrifugal force in aikido techniques can be seen very well in the consecutive frames of video footage of such techniques. Centrifugal force is important in aikido techniques since it is that part of resultant force which causes loss of balance. It is also important because it reveals the correct use of a technique in which it is crucial to redirect the attacker's force. Regardless of the type of attack, while using an aikido technique the defender should be as close as possible to the centre of the rotation with the attacker on its perimeter. The total moment of inertia of the attacker-defender system can be described using Steiner's theorem [1].

In approximation it can be said that the principle of conservation of angular momentum is at work here. In order to increase the attacker's angular velocity the defender has to decrease the moment of inertia by getting his body parts as close as possible to the axis of rotation. Mistakes in the execution of a technique thwart the achievement of this goal. For instance, leaning forward too much does not produce the necessary decrease in the moment of inertia with regard to the vertical axis of the system [1, 2]. The trunk should be held vertically so as to minimise the moment of inertia. At the same time it is important to reduce the radius of the curvilinear movement of the attacker.

The aim of the research was to answer the questions: a) whether way the kind of manner of conducting aikido class can influence the efficiency of mastering aikido techniques; b) in what way biomechanical knowledge on the mechanics principles applied in aikido techniques, can impact the correctness of performance.

Martial arts – *plural noun* any of various systems of combat and self-defence, e.g. judo or karate, developed especially in Japan and Korea and now usually practised as a sport [26].

Motor safety – is consciousness of the person undertaking to solve a motor task or consciousness the subject who has the right to encourage and even enforce from this person that would perform the motor activity, who is able to do it without the risk of the loss of life, injuries or other adverse health effects [27].

PE – *abbreviation* physical education [26].

Physical activity – *noun* exercise and general movement that a person carries out as part of their day [27].

Technique – *noun* a way of performing an action [26].

Rotating training simulator – as an apparatus that can exercise three functions: determining the moment of inertia, improving motor habits while performing certain "rotation techniques" in various sports disciplines, simulating the effect of the external force as the cause of losing balance and falling by a man who originally was immobile (standing, sitting, kneeling, etc) [7].

Position – *noun* **1**. the place where a player is standing or playing **2.** the way in which a person's body is arranged [26].

MATERIAL AND METHODS

Participants

The research involved a cohort of 51 students of Physical Education, aged 21.9 ±2.3, who participated in aikido classes over a two-year period (2012-2013) as part of their programme at the university. They were randomly divided into two groups: A (n = 24) students who additionally practised with a rotating training simulator: B (n = 26) students practised aikido the traditional way – without the aid of a rotating training simulator.

Study design

The traditional method consists in learners imitating the moves of the master. In Group A the learners' knowledge of principles of biomechanics was used to explain aikido techniques. Having mastered safe falling, the students were taught four aikido techniques for a period of one month.

The techniques taught to the students were the same as previously used by this author in research on children [3]. The name of an aikido technique contains the description of the way the attack is neutralised when using it [4, 5]. The method of neutralisation is at the same time connected with the execution of a specific movement. In the techniques used in the research the defender finished off the neutralisation of the attack with a throw of the *hikiotosu* type. The *hikiotosu* techniques involve pulling the attacker downward [6] – which is also used in sumo and judo. Often in the execution of those techniques the defender moves along an arc and optimally lowers his centre of gravity. As a result, when executing the throw the defender takes advantage of both the centrifugal force acting on the attacker and his own body weight. In the research training the *kokyu nage* throwing techniques were taught. Two of them were taught as a response

to 'katatedori ryotemochi' attack, one other – to *yokomen uchi*, and another – to *ryokatadori*. The instruction for the learners emphasised the optimal use of the centrifugal force.

The execution of each technique was assessed using a ten-point scale and the video footage. The techniques were executed in a slowed-down manner so as to limit the effect of particular students' motor abilities on the effectiveness of execution.

In the research training, Group A students practised aikido using a rotating training simulator. The device is constructed in such a way that it marks the training person's moment of inertia, aids learning particular movements in rotation, and helps diagnose fall habits [7, 8].

The rotating training simulator was used in the research to present the principles of rotating movement and improve movements in the execution of aikido techniques. The trainer was previously used by this author in another research involving aikido instruction and described in a scientific paper [2]. Practising with the rotating training simulator, the students adopted a particular position on the turntable (Figure 1) holding metal bars – which imitated holding the opponent by the judogi. The electric motor set the turntable spinning. Having reached the desired velocity it was switched off by means of a clutch, letting the turntable revolve freely. With the power cut off it was also possible to add angular momentum to the training person by means of an external force, e.g. by pushing the bars. Having reached a specific rotational velocity the training person got closer to the bars or departed from them.

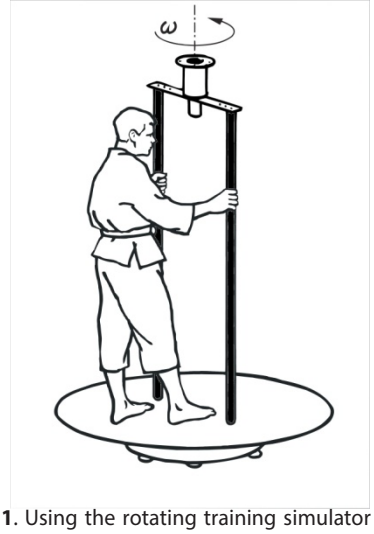

Figure 1. Using the rotating training simulator in the training mode.

In the initial phase of the training sessions the students went solo on the turntable. Standing at a distance from the bars (Figure 1) at a specific rotating velocity they moved to the centre of the turntable. They adopted a posture which resembled the natural *shizen-tai* position recommended for performing aikido and judo techniques [9, 10]. By moving to the centre of the turntable the students decreased the total moment of inertia of the student-and-revolving-parts-of-trainer system, causing the angular velocity to rise – in accordance with the principle of conservation of angular momentum.

This task was performed correctly when performed according to the instruction by the instructor – and incorrectly when the student bent his head and trunk forward or did not get close enough to the axis of the spin. In this way the students could feel the changes of their angular velocity – when they were small or big. In the next phase, two students went on the turntable and they got nearer or moved away from the axis while holding the bars. The students were made aware that the defender's centre of gravity was to move close to the centre of rotation which would increase the centrifugal force acting on the attacker [1, 2]. The rotating training simulator enabled the students to understand how the changes in angular velocity were dependent on the changes in the distance between body segments and the axis of rotation.

It can be assumed that the turntable is an approximation of the movement of students practising on mattresses. The acceleration of spinning as can be felt on the rotating training simulator is stronger than it occurs in the normal execution of a technique, which makes the student feel better how a particular body movement can trigger changes of the spinning movement during the execution of a technique.

The rotating training simulator enables the student to practise on condition that the student holds the bar with one hand (Figure 1) – otherwise the student might get slung off the turntable by the centrifugal force acting on him when the moment of inertia is radically diminished. In aikido techniques involving rotation the attacker

and defendant are bound together by means of a grab even if the technique begins with a strike or anything different from a grab. That is why the rotating training simulator can imitate accelerations experienced by students executing various aikido techniques as a response to various forms of attack and at the same time it can help students understand the principles of mechanics which are at work in those techniques.

Group A students did a written test checking their understanding of mechanics of rotation.

Statistical analysis

The results were analysed using mathematical statistics, including regression analysis and t-Student test for independent variables.

RESULTS

For the performance, group A scored much higher average value in comparison to group B (Figure 2). At the same time it was concluded that the differences between the groups were statistically relevant for $p<0,05$.

Using regression analysis, a relevant correlation ($r = 0.74$) was observed between answering the question correctly in the subject of biomechanics and the precision of performing aikido techniques (Figure 3).

DISCUSSION

Bending the trunk and head forward too much by the defendant is a common mistake in the execution of aikido techniques involving spinning motion [1, 2]. Making this mistake while practising with a rotating training simulator results in weaker accelerations. Adopting a proper body position when coming up on the turntable, between the bars, from the position shown in Figure 1 results in much better accelerations – it is difficult, especially for beginners, to reach such accelerations when practising with a partner on a mattress. In this author's view, practising on the rotating training simulator, by exercising the student's sense of balance, gives the student an experience of movement which leaves its mark in the student's motor memory.

During the practice, the instructor explained to the students, quoting principles of mechanics, which move by the defender can increase the centrifugal force acting on the attacker. As a result, Group A students were able to understand principles of mechanics involved in aikido techniques. The use of the rotating training simulator with Group A students caused them to get better assessment thanks to maintaining proper position during the execution of the technique and decreasing their curvilinear movement with which to obtain an optimal centrifugal force acting on the attacker. Numerous researchers have noted the importance of the proper position in judo and aikido [6, 9-11].

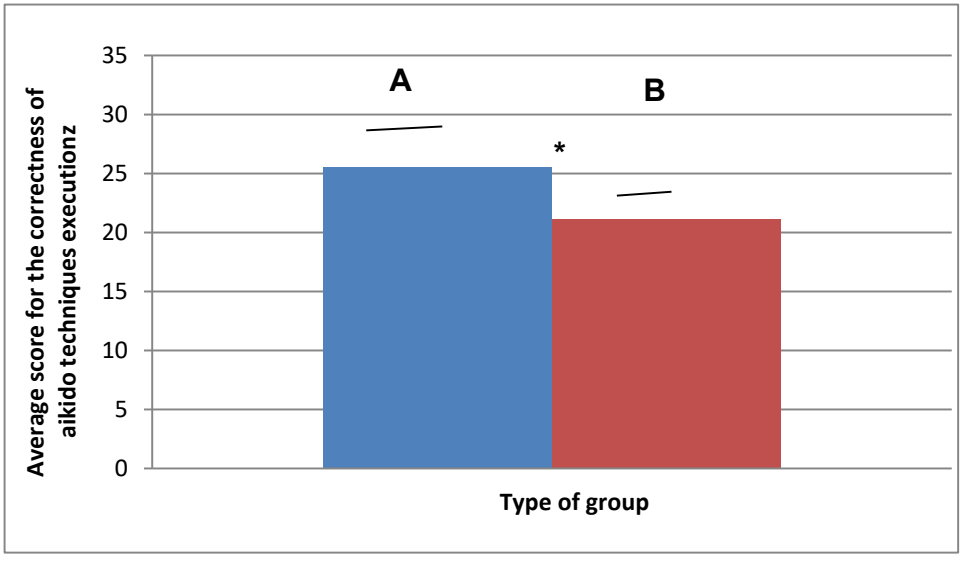

Figure 2. Average scores of children in both groups for the execution of aikido techniques. An asterisk (*) marks the statistically significant difference between the group results at $p<0.05$.

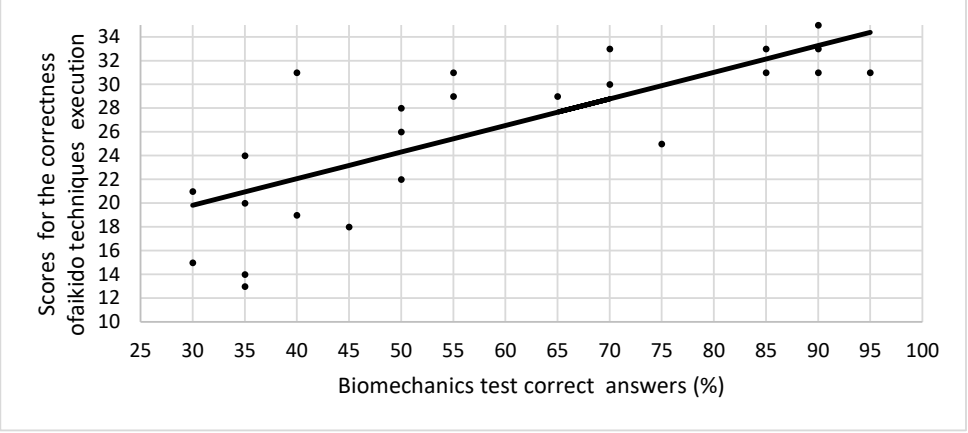

Figure 3. Correlation between the scores for the execution of aikido techniques and the correctness of answers to questions on biomechanics in Group A (n = 24). Simple regression equation: y = 13.098 + 0.22404 x, r = 0.74.

Jigorō Kano believed that his creation, judo, was supposed not only to develop as a sports discipline, but also as a wide-scope martial art. He reproached students for bending the head and trunk too much, which, in his view, diminished chances of a quick counter-technique in judo. It lessened the effectiveness of defence from a strike or kick. According to Jigorō Kano, this could be remedied by exercising more care of a proper position in combat, the so-called *shizen-tai* [10]. It can be assumed that it this position that was taught to the students in the research described here.

The findings suggest that the use of the rotating training simulator sped up the acquisition of those aikido techniques which involve rotating movement. This author obtained the same results in another research where the rotating training simulator was used to teach the *ryokat-adori kokyo nage* technique – used as a defence from the 'randori' style fast attack [2]. This article looks at the acquisition of four types of techniques with slowed-down execution. Positive correlations were found between the correctness of the execution and the results of the test on the understanding of principles of mechanics relative to rotation used in the execution. Such findings suggest that the understanding of those principles accelerated the acquisition of aikido techniques. Similar research was carried out by this author on primary-school and secondary-school students and similar correlations were found [1, 5]. In those researches, however, explaining aikido techniques was done without the aid of the rotating training simulator because it had not been constructed yet. It is difficult to compare the results by this author in the previous researches since the cohorts involved were of varying ages, from various selections. In this author's view the rotating training simulator is a very useful instrument for experimental presentation of the principles of rotation which are used in the execution of aikido techniques. The rotating training simulator provides supplementary explanation of those principles when practising techniques on mattresses.

No other researchers have dealt with the methodology of teaching aikido on the basis of understanding the principles of mechanics. The teaching of aikido mostly relies on the imitation of the teacher's moves without any biomechanical analysis. Such a method is often used in sports, as is confirmed by course books on biomechanics. The development of biomechanics suggests, however, that the concept of motor teaching which relies on the awareness and understanding of a particular kind of movement is fully justified [12]. It makes easier not only the repetition of moves practised already but also the development of new ones according to a new goal.

There are publications which report the use of physical education in the teaching of mathematics or Polish – by means of 'eduballs' [13, 14]. Engaging students in physical activity facilitates the teaching. In his research, this author found that secondary-school students scored better in tests on mechanics of rotation due to their participation in aikido classes during which principles of mechanics of rotation were explained [1, 5]. In

this author's view, the use of a rotating training simulator makes it possible to teach mechanics of rotation through the students' direct participation in rotation [7]. Such a way of teaching can bring about positive results – in accordance with a sustainability principle: stimulating as many senses as possible [15]. Apart from the senses routinely employed in teaching, sight and hearing, other senses, including somatic ones, can be used. The senses of touch and balance. i.e. the kinaesthetic sense, are activated with this method of teaching. The biomechanics used for instruction is a form of 'live mechanics' [1] involving the participation of the student instead of an object used as a teaching aid in physics classes. Experiments have shown that knowledge of mechanics taught this way is effectively acquired [1, 3, 5].

The rotating training simulator can find wider application in training routines in numerous sports disciplines which involve intense rotary movement. It can be used for improving balance skills [2]. Many authors [16-18] stress the importance of developing the sense of balance and high motor coordination in martial arts. Such skills are assessed by means of Kalina's rotary test [19] or Starosta's global coordination test [20, 21].

The research on aikido and biomechanics so far has focused on improving the use of the centrifugal force acting on the attacker. However, the force causing the attacker to fall is a resultant force of the centrifugal force and the force derived chiefly from the defender's weight [1]. There are no scientific reports on the effectiveness of the use of the latter force which, too, contributes significantly to the attacker's fall. With regard to the weight-derived force, research would require a different aid than the rotating training simulator. Such research could explain the reasons for the fall of the attacker which are often unintelligible to the public watching masters in action. At the same time it would be possible to confirm the validity of biomechanical assumptions concerning forces generated in the execution of aikido techniques.

In this author's opinion, the ability to make use of the force derived from the weight of the defender is only achieved by veteran practitioners and also depends on the style of aikido. It should be noted that practising with a rotating training simulator helps the student adopt a correct body position so as to obtain optimal force originating in the defender's weight.

The knowledge the students gained in the experiment helped accelerate their acquisition of self-defence aikido techniques. However, the knowledge gained through practice with a rotating training simulator may in future be of bigger importance to students of physical education. The prospective PE teachers really should understand the principles of mechanics applicable to rotary motion because of safety concerns in the gym. It is especially important in the case of gymnastic exercises involving dynamic rotary movement. A wrong move may lead to, for instance, a dangerous fall.

The subject matter of this article falls within the scope of agonology or the theory of fighting, an interdisciplinary field [22]. Mroczkowski has proved with regard to biomechanics that using aikido techniques is done by means of the clever use of the attacker's power, which underlines aikido's truly defensive character [1]. Through knowledge and training the practitioner achieves a preventive effect (by developing his own courage) and a therapeutic effect (by reducing his potential susceptibility to destruct himself and harm another) [22] – which is significant in light of agonology. Such a kind of self-defence can be seen as honourable self-defence [23]. Aikido can be useful for self-defence, health, and cognitive purposes with its reliance on biomechanics. Given such prospects this kind of activity can be part of the chief mission of agonology in respect of health problems prevention and therapy [22, 24, 25].

CONCLUSIONS

Understanding the principles of mechanics which are at work in aikido techniques contributes to the correctness of execution. Using a rotating training simulator for aikido training caused the students to reduce the radius of their curvilinear motion in the execution of techniques, thus increasing the centrifugal force acting on the attacker. Moreover, teaches students not to bend the trunk and head too much (doing so being a common mistake) during the execution of techniques.

It is possible to teach students effectively the principles of rotary motion in aikido classes. Using knowledge of biomechanics and a rotating training simulator in the teaching of aikido techniques results in better acquisition of those techniques than is the case with the traditional aikido instruction.

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