The following article is a continuation of my earlier studies concerning combining knowledge from PE classes and teaching physics [1]. The results obtained pointed to a significant improvement of the secondary school students’ understanding of the principles of mechanics taught during physics classes when using examples from PE classes. The observations of mechanical movement performance of students during their PE classes were used in teaching physics. For example, a shot putting exercise was used to demonstrate that students who understood the mechanics of the particular sport, significantly increased their putting range, after having changed their putting technique. It was also observed that understanding the principles of mechanics could be very useful in extracurricular forms of physical activity. The research conducted showed that teaching aikido techniques was more effective if their dynamics was explained using principles of mechanics [1, 2]. The aim of the following study was to assess whether the level of knowledge about principles of mechanics in aikido affects the precision of aikido movements execution. The other research question was whether teaching solid-state mechanics using examples from aikido and other sports could increase teaching effectiveness.

**Material and methods**

The samples for the study consisted of two groups of secondary school students from the city of Kolo. All subjects had participated in similar studies in the school year 2000/2001, when they were in the first grade [1]. The two study groups were in fact two school classes E and F. Group E (control group) comprised 33 students, and group F (experimental group) included 27 students. In the first semester of the school year 2001/2002 group F (second secondary school grade) practiced aikido one hour a week. Solid-state mechanics is part of physics curriculum in the third grade of secondary-school, after students acquire sufficient mathematical skills in their
lower grades. Before the commencement of the mechanics course in the school year 2002/2003 students had to pass a physics revision test covering material from the first grade, i.e. translational mechanics (Test 1). Solid-state mechanics was taught in class E in the traditional way, whereas students from class F used their experiences and examples from aikido and other sports, e.g. by analyzing mechanical movements during diving, sports gymnastics, dancing, figure skating, etc. Both groups then took a final test to assess their learning outcomes. Both tests (1 and 2) were surprise tests and were carried out some time after the last class to ensure assessment of students’ understanding of the mechanics principles, and not merely their memorizing skills.

In the experimental group the dynamics of aikido techniques was taught using principles of biomechanics, i.e. mechanics principles of human movement. In the description of human movement the human body is divided into 14 parts treated as solids [3]. The classes focused mostly on the solid-state rotational mechanics. The basic principles of mechanics in aikido techniques were the subject of my earlier study [2]. The students taking the mechanics classes were informed about the advantages of reducing the radius of performed movements, the distance between the arms and the axis of rotation, or of lowering or optimal shifting the body’s center of gravity. The principles of aikido such as “yield to win”, “turn around if you’re pushed” or “move forward if you’re pulled” were explained to the students using the law of momentum conservation, second law of motion for angular motion, centrifugal force and composition of resultant forces and moments of force [2, 4].

The students’ knowledge of biomechanics for aikido was tested in an essay form. After writing their essays the students got acquainted with four selected aikido techniques during one month. Then the precision of performance of each technique was assessed using a ten-point scale. Each subject could score up to 40 points. The method of evaluation of aikido technique performance was taken from the Koichi Tohei aikido school1. As sports rivalry does not apply in aikido practitioners are evaluated on their performance of taigi, i.e. sets of techniques executed in response to a particular attack [4, 5]. Both the precision and speed of movements are evaluated. During the study only the precision of movement sequences performed by a practitioner was assessed. The precision criteria included an appropriate reduction of the radius of motion, assuming proper body posture, arms movement and shifting the body’s center of gravity at a given movement.

Before learning the selected techniques the students taking part in the test had already acquired basic aikido skills, i.e. safe falls [6], body turns and rotations. The assumed method of instruction was “from the general to the specific” [4]. First, general rules of technique execution were explained, followed by a detailed analysis of particular movement sequences in a given technique. Student’s t-test for independent variables and regression analysis were used in statistical analysis.

**Results**

The effects of the mean results of the written tests in both groups were assessed using Student’s t-test for independent variables. No statistically significant differences were observed between group E and group F in test 1, but not in test 2 ($p < 0.05$) (Fig. 1), where group F attained a much higher mean result than group E.

![Figure 1. The mean results of mechanics tests taken by students from group E (taught in the conventional way) ($n = 33$) and from group F (taught using examples from aikido and other sports) ($n = 27$) with statistically significant difference between the groups in test 2, at $p < 0.05$](image_url)

The obtained Student’s t-test results were confirmed by results of non-parametric U-Mann Whitney test. The analysis of regression was used to examine the correlation between the correctness of biomechanics test answers and precision of performance of aikido techniques. A strong correlation was noted between the two at $r = 0.9$.

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The results confirm that the knowledge of biomechanics in teaching aikido techniques affects the precision of performance of a given technique (Fig. 2). The term “aikido technique” must, however, be precisely defined. There are multiple definitions of “sport technique” in professional literature. Bober [8] in his analysis of definitions of sports technique follows Zatsiorsky [9], who thinks sport technique is a term which can be described rather than defined. In my opinion the term aikido technique refers to a way of neutralizing a specific attack and simultaneous execution of a specific motor task. Neutralizing can be made by (1) locking, (2) throwing or (3) a combination of both [10]. The neutralizing technique differs with regard to the type of attack. The study revealed a strong correlation between the learnt knowledge of biomechanics and the number of points scored for execution of aikido techniques. Similar results had been attained during teaching shot putting techniques [1]. The putting distance increased in students who had learnt about the mechanics of this particular field event.

The study can be confirmed by Bober and Zawadzki [11], who observed that the concepts of motor learning refer to the learner’s task awareness and understanding during learning a specific motor pattern. Not only then does reproduction of motor patterns practiced earlier become easier, but also creation of new ones. The examples of applying knowledge of the principles of mechanics in aikido or shot put training point to the need to use biomechanical knowledge in teaching all sports or physical recreation. In my opinion this knowledge is not always effectively used by physical education teachers. Carrying out a thorough biomechanical analysis of sports techniques during PE classes, rather than giving mere instructions to students seems reasonable. Teaching an infinite number of movement sequences requires the knowledge of laws of translation and rotation [2]. The teacher’s role is to know these laws as they can be very useful in students’ learning of specific motor tasks.

**Conclusions**

1. Understanding the principles of mechanics during execution of aikido techniques increases the precision of their performance.

2. Teaching solid-state mechanics using examples from aikido and other sports is more effective than the conventional methods of physics teaching.
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A. Mroczkowski. The use of biomechanics in teaching aikido

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Paper received by the Editors: June 23, 2008.
Paper accepted for publication: November 6, 2008.

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