The spine mobility of karate master class contestants

Arletta Hawrylak[1ABCD], Krystyna Chromik[2BDE], Katarzyna Barczyk-Pawelec[1ACD], Ewa Demczuk-Włodarczyk[1ADE]

[1] Faculty of Physiotherapy, Department of Physiotherapy, University School of Physical Education in Wroclaw, Wroclaw, Poland
[2] Faculty of Sport Science, Department of Physical Anthropology, University School of Physical Education in Wroclaw, Wroclaw, Poland

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Abstract

Background and Study Aim: Karate is one of the most popular martial arts practised all over the world. Karate training puts considerable strain on peripheral joints, and rotational movements of the spine may considerably influence its mobility. The aim of this paper is the knowledge about the mobility of particular sections of the spine of karate national team contestants compared to people who do not practise any sports disciplines.

Material and Methods: Thirty-eight men (aged 26.8 ±4.67).19 *kumite* contestants and 19 control group. The assessment of the spine mobility in sagittal plane, frontal plane, and transverse plane was performed with the use of a universal Saunders inclinometer according to generally accepted principles

Results: Ranges of the spine mobility oscillated within assumed standards in both groups. Statistically significant higher values of the spine mobility range were obtained by those who trained karate and referred to the range of the lumbar spine flexion towards a dominant limb and a non-dominant limb as well as a movement of the thoracic section of the spine towards a non-dominant limb (p≤0.05).

Conclusions: Long-term karate training results in an increased mobility of the spine in training individuals compared to their non-training peers. In karate practitioners, lower values in relation to the standard were observed only within the range of extension of the lumbar section and flexion of the cervical and lumbar spine. This indicates the need to introduce specialist exercises to the training to compensate for the deficiencies of the spine mobility.

Keywords: combat sports • injuries • kumite • martial arts • Saunders inclinometer

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Author's address: Krystyna Chromik, Faculty of Sport Science, Department of Athletes Motor Skills; University School of Physical Education in Wroclaw, al. I.J. Paderewskiego 35, 51-612 Wroclaw, Poland; e-mail: krystynachromik@gmail.com

Martial Arts – are systems of fight practices (practised for many reasons: self-defence, competition, self-improvement, physical health and fitness, mental and physical development) [40].

Combat sports – are competitive contact sports with one-on-one combat. Determining the winner depends on the particular contest's rules. In many combat sports, a contestant wins by scoring more points than the opponent or by disabling opponent [40].

Dan – *noun* **1.** one of the numbered black-belt levels of proficiency in martial arts such as judo and taekwondo. Also called **dan grade 2.** somebody who has achieved a dan [39].

Dan (dan'i) – a term used to denote one's technical level or grade [41].

Kyū (**kyu**) – is a Japanese term used in modern martial arts (in judo from **6** to **1 kyu**; which is the highest) as well as in tea ceremony, flower arranging.

Injury – *noun* damage or a wound caused to a person's body [39].

Mobility – *noun* the ability to move about mobility training [39].

Mobility training – *noun* exercises that increase the range of movement of the joints [39].

Technique– *noun* a way of performing an action [39].

Technique – specific procedures to move one's body to perform the task that needs to be accomplished [42].

Tactics – decisions and actions of players in the contest to gain an advantage over the opposing players [42].

Global science space – conventionally, the global science space is associated with the ability to provide the latest scientific knowledge through prestigious electronic scientific journals [8].

INTRODUCTION

Karate is one of the most popular martial arts practised all over the world [1]. The World Karate Federation tournaments consist of two equally important disciplines: *kumite* and *kata*. *Kumite* is a synonym for the fight which usually consists of the phases of attack and defence until one of the opponents breaks another opponent's defence and carries out assault on the latter's central line. *Kata* is a type of training of special set sequences and techniques which imitate real fighting carried out according to certain rhythm and order [2, 3]. It is not only meeting the requirements for particular *kyu* or *dan* levels of advancement that testify to the level of a karate athletes achievements but also their success in a sports competition. Competent karate practitioner uses the scientific basis of attack and defence and their strengths to dominate their opponent. A way in which a fight is carried out depends on an individual fighter, and indicators of technical and tactical preparation also include information on contestants' physical and psychological preparation [4-7].

The flexibility of the motor system is one of the basic features which influence the effectiveness of athletes who do karate. It is necessary to perform a high kick or to make a full range motion at a great speed. It can not only facilitate the performance of many techniques but also help prevent injuries. Karate training puts considerable strain on peripheral joints, and rotational movements of the spine may considerably influence its mobility. At present, there are very few reports on the assessment of flexibility in the practitioners of this sports discipline [4].

A science of martial arts (in the sense of recognition as a sub-discipline in the global science space [8]) is a young and still developing area in Poland and other countries [9]. A lot of scientific papers (last 5 years) have been written on psychophysical (also nutrition, body composition) [6, 10-12], biomechanical and motor control [7, 13-16], rehabilitation [17, 18] sports services [19] aspects associated with karate training. However, the available literature does not include many reports on the spine mobility of karate athletes.

The aim of this paper is the knowledge about the mobility of particular sections of the spine of the karate national team contestants compared to people who do not practise any sports disciplines.

MATERIAL AND METHODS

Participants

The study material was divided into two groups. Group 1 consisted of the team of AZS Polish WKF Karate Championships, Wrocław 2012 as well as the team of the elimination tournament for WKF World University Championships in Bratysława (19 contestants of the karate Shotokan section of AZS University of Environmental and Life Sciences in Wrocław aged 23.36 ±1.27 years; body mass 79.5 ±8.35 kg; body height 186.4 ±2.67 cm; BMI 22.8 ±1.17; training experience 10.5 ±.71 years; the level of advancement was from 4 kyu to 4 dan). Group 2 (control) consisted of 19 students of University School of Physical Education in Wroclaw, Poland who did not practise any sports discipline (aged 22.43±1.9 years; body mass 81.73 ±7.39 kg; body height 182.87 ±5.14 cm; BMI 24.1 ±2.17).

A criterion for including a contestant in the study was his written consent for taking part in it, his age 20-25 and membership of the karate section in the case of group 1 whereas not doing any sports discipline was a criterion for the subjects of group 2. A criterion for excluding a contestant from the study was as follows: injuries which were being treated at that moment and a lack of consent for taking part in the study.

The study was carried out according to the principles of the Declaration of Helsinki in 1975 amended in 2000. All procedures were approved of by the Ethical Committee of University School of Physical Education in Wroclaw. Before the study experiment, all participants obtained full explanation regarding the objectives and procedures of the study.

Procedures

The measurements were performed with the use of a universal Saunders inclinometer (Digital Inclinometer, model 12-1057, Baseline Evaluation Instruments) Calibration was unnecessary as an inclinometer can be reset anywhere in range. The measurements were conducted according to the guidelines of American Medical Association (AMA) [20]. The measuring error determined by the inclinometer was determined by Czaprowski et al. [21], In the range of 2.8˚ to 3.8˚. Three subsequent trials were carried out, and a mean value was calculated for them. The study was conducted within a single series of the spine mobility measurements. The research was carried out in the same laboratory of the

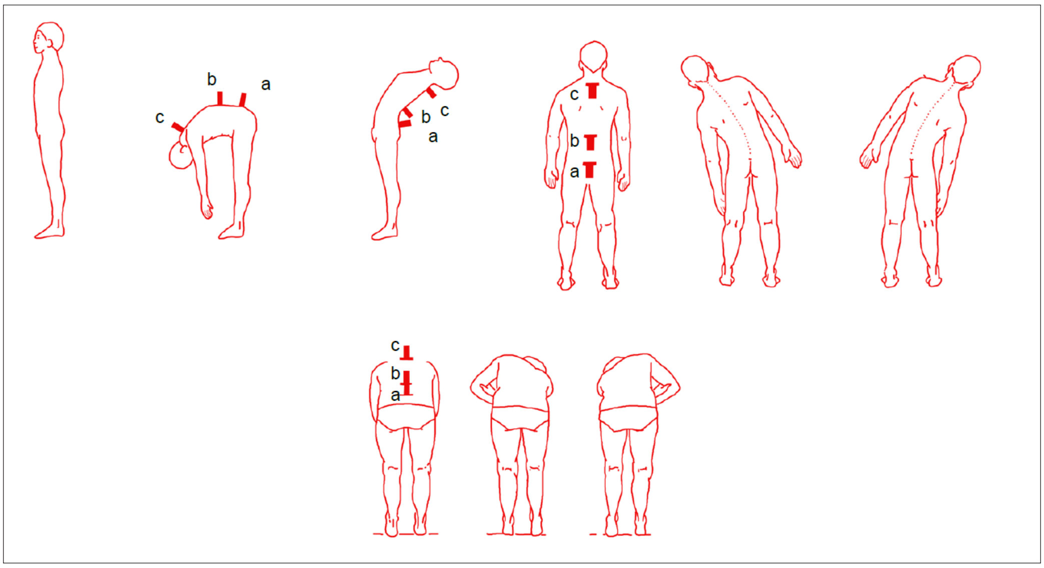

Figure 1. Measurement of the sagittal, frontal, and transverse plane of the thoracic and lumbar spine [20]. Own preparation in accordance with Saunders methodology.

Academy of Physical Education – an institution of university type providing education in the field of sport science, having full academic rights (from bachelor to a professor with the right to confer a "***doctor honoris causa***" title). In Poland, there are six academies of physical education: the Academy of Physical Education in Katowice, Krakow, Poznan, Warsaw, Wroclaw and the Academy of Physical Education and Sport in Gdansk [43]. The official name in the English language of the university is the University School of Physical Education in Wroclaw.

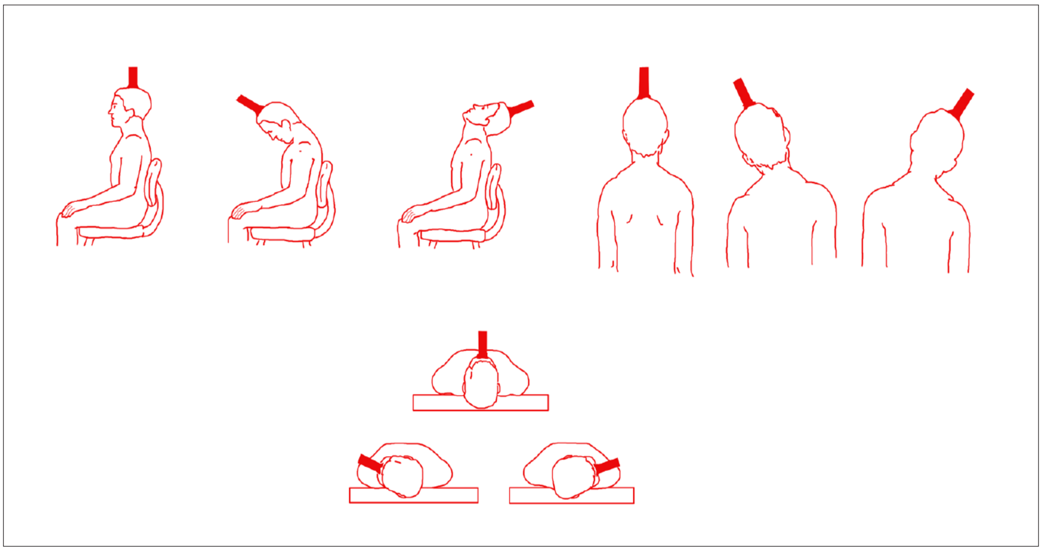

Figure 2. Measurement of the sagittal, frontal, and transverse plane of the cervical spine [20]. Own preparation in accordance with Saunders methodology.

Department of Physiotherapy, University School of Physical Education in Wroclaw (Poland). All subjects were measured by the same person.

Ranges of mobility were assessed with the use of AMA indication method in the following planes [20]: in the sagittal plane (flexion and extension of the lumbar, thoracic, and cervical spine); in the frontal plane (lateral flexion of the lumbar, thoracic, and cervical spine); in the transverse plane (rotation of the lumbar, thoracic, and cervical spine).

To assess ranges of mobility in the subjects, the following reference points were marked [20]: medial point of the sacrum (point A); disc space Th12-L1 (point B); disc space C7-Th12 (point C). The measurements were carried out according to the following scheme (Figures 1 and 2):

Also, a body height (BH) and body mass (BM) were measured with accuracy to 0.5 cm and 0.1 kg, respectively. Then, a body mass index was calculated (BMI = BM/BH2). The measurements were taken by the same scholar according to standard procedures.

Statistical analysis

For the calculations, standard descriptive statistics, i.e. the mean value, standard deviations were applied, which were calculated for each variable.

Table 1. Standard, mean values and standard deviations of spine mobility ranges in the sagittal plane and their statistical significance between the karate athletes (group 1) and a non-training sport (group 2).

Variable	Standard	Group1 (n = 19)	Group 2 (n = 19)
FFCS	≥60	56.00 ±12.81	54.74 ±10.31
ECS	≥75	76.00 ±13.92	77.53 ±8.02
FTS	20 to 30	26.89 ±6.43	26.74 ±13.09
ETS	20 to 35	45.89 ±19.62	37.47 ±19.02
FFLS	≥ 60	55.11 ±10.76	57.32 ±7.76
ELS	25	23.68 ±12.89	23.68 ±7.10

Legend: **FFCS** forward flexion of the cervical spine; **ECS** extension of the cervical spine; **FTS** flexion of the thoracic spine; **ETS** extension of the thoracic spine; **FFLS** forward flexion of the lumbar spine; **ELS** extension of the lumbar spine.

Table 2. Standards, mean values and standard deviations of spine mobility range in the frontal and transverse plane and their statistical significance between the karate athletes (group 1) and a non-training sport (group 2).

Variable	Standard	Group1 (n = 19)	Group 2 (n = 19)
FCSDL	≥45	58.42 ±7.66	54.84 ±8.27
FCSNDL	≥45	55.78 ±5.62	59.26 ±6.83
RCSDL	≥80	87.52 ±3.74	85.58 ±6.94
RCSNDL	≥0	87.21 ±3.96	83.94 ±3.81
FLSDL	20 to 30	**34.00 ±13.56****	**21.58 ±10.37****
FLSNDL	20 to 30	**37.73 ±8.04***	**31.52 ±8.87***
RLSDL	5 to 10	8.21 ±4.54	10.36 ±5.27
RLSNDL	5 to 10	7.63 ±5.29	8.31 ±6.48
RTSDL	20 to 30	30.73 ±7.14	24.89 ±10.68
RTSNDL	20 to 30	**26.63 ±12.44***	**15.78±10.21***

Legend: **FCSDL** flexion of the cervical spine towards a dominant limb; **FCSNDL** flexion of the cervical spine towards a non-dominant limb; **RCSDL** rotation of the cervical spine towards a dominant limb; **RCSNDL** rotation of the cervical spine towards a non-dominant limb; **FLSDL** flexion of the lumbar spine towards a dominant limb; **FLSNDL** flexion of the lumbar spine towards a non-dominant limb; **RLSDL** rotation of the lumbar spine towards a dominant limb; **RLSNDL** rotation o of the lumbar spine towards a non-dominant limb; **RTSDL** rotation of the thoracic spine towards a dominant limb; **RTSNDL** rotation of the thoracic spine towards a non-dominant limb; *p≤0.05, **p≤0.01.

Significant differences between the groups were examined using the t-Student test (p≤0.05). All statistical tests were carried out with the use of the following programmes: Statistica 12.0 PL and Microsoft Office Excel 2010.

RESULTS

Ranges of the spine mobility oscillated within the standards except for a range of motion for flexion of the cervical spine and the lumbar spine mobility (flexion and extension). No statistically

Table 3. Standards, mean values and standard deviations of spine mobility range in the frontal and transverse plane and their statistical significance between a dominant limb (DL) and non-dominant limb (NDL) karate athletes (n = 19).

Variable	Standard	DL	NDL
FFCS	≥45	58.42 ±7.66	55.78 ±5.62
RCS	≥80	87.52 ±3.74	87.21±3.96
FFLS	20 to 30	34.00 ±13.56	37.73 ±8.04
RLS	5 to 10	8.21 ±4.54	7.63 ±5.29
RTS	20 to 30	30.73 ±7.14	26.63 ±12.44

Legend: **FFCS** forward flexion of the cervical spine; **RCS** rotation of the cervical spine; **FFLS** forward flexion of the lumbar spine; RLS rotation of the lumbar spine; RTS –rotation of the thoracic spine.

significant differences within the spine mobility were found between the groups studied (Table 1).

The values of the ranges mentioned above were within the limits of the determined standards. Statistically significant higher values the spine mobility range were obtained by those individuals who trained karate and regarded a range of flexion of the lumbar spine towards a dominant limb and a non-dominant limb and rotational movements of the thoracic spine towards a non-dominant limb (Table 2).

All ranges of the spine mobility fell within the limits of physiological standards (only karate athletes). Slightly lower values were received for the spine mobility towards a non-dominant limb. No statistically significant differences within the spine mobility were found in its particular sections depending on a dominant limb or a non-dominant limb (Table 3).

DISCUSSION

On the basis of reports of many authors, it was found that doing most of sports disciplines may cause physical and physiological adaptations in a motor organ, which may lead to positive changes in flexibility and strength of the ligament and muscular system [7, 10-12, 20-22]. However, doing combat sports can also result in negative changes associated with excessive developing of muscle strength and flexibility mainly on one side of the body, which may lead to an imbalance of muscular tension in the muscular system and therefore it considerably increases a risk of injury [23, 24].

In martial arts, it is particularly important to notice each move of an opponent to apply an effective defensive or attacking technique. Thus, an individual who practices karate can conclude from the opponent's position and movement what their intentions are [24]. Tactics in a combat sport are described as a way of executing sports activity justified through proper evaluation of one's own and the opponent's abilities as well as evaluation of the given situation. It is reduced to the choice and performance of the most purposeful actions to achieve success exerting minimal force [25]. According to Filingeri et al. [7] and Kalina [26], special fitness in martial arts and combat sports is a manifestation of an adaptation of an organism to specific fitness and functional requirements needed in a direct fight of two individuals. Moves in karate can be reduced to such a few groups as blows, kicks, pushes or pulls as well as defensive actions adjusted to block against an attack. *Kumite* is a type of sports fight in which one scores points through hitting, by means of blows and kicks, proper areas on the opponent's body for which points are scored such as chest, back excluding shoulders, head excluding neck, and, at the same time, it is essential that these techniques should be controlled [26].

Developing flexibility should take place at each training session following the warm-up (regular practice is of great importance for this feature [27, 28]). Flexibility development methodology consists mainly of doing exercises with an increased amplitude of movements, or stretching exercises. The exercises should be done both in an active way, i.e. using one's muscles and in a passive way – using grips and the partner. However, it ought to be remembered that one should not work out too high joint mobility as it may lead to decrease body stability causing dispersion of working forces. This, in turn, requires extra flexing of muscles in one's movements when particular sections of the body must be stabilised to hold a great load, e.g. during a fight, this may have an impact on reducing one's resistance to blows.

Thus, in the training process, one should not aim at the maximum development of their flexibility but at an optimum level at which necessary moves and techniques are performed fluently. Similarly, one should not go to the other extreme in karate, i.e. practising only strength training, in which flexibility exercises are skipped for a longer period. This may lead to limitation of joint mobility and muscle and tendon flexibility as a result of flexing muscles too hard [29, 30]. In available literature, there is no scientific report concerning the assessment of vertebral motion in karate athletes using the Saunders inclinometer. According to Czaprowski et al. [21], this device is used for functional analysis of the motion system. For measurements made by one investigator who has experience in using an inclinometer, good repeatability can be obtained. However, the error of the order of 2.8˚ to 3.8˚ should be taken into account when interpreting the results.

Limitation of the cervical spine mobility observed in the authors' study can be connected with habitual aggressive flexion of this body part during a fight [31]. According to Sterkowicz and Franchini [5], a physical impact a karate practitioner has on his opponent during a training fight and competitions may cause considerable disturbance in activities of different body systems. The most vulnerable spots on the body are: spine, head, and neck but are not limited to them, which lie in the so-called central line. Here, there are the main attack/defence points. The study conducted by Arriaza and Leyes [32] proves that the most injuries which occur during the karate competitions regard face and head, which may result in changes in the cervical spine, pain in this body part and mobility limitations. A decrease in a range of mobility in this body part may also result from the use of a simple blow from an upper limb called *chudan-seiken-tsuki*. According to Sterkowicz and Franchini [5] and also other authors [23, 32], it is the most effective punching technique.

According to Zetaruk et al. [1], a decrease in the range of the lumbar spine mobility in karate practitioners may result from the fact that this section of the spine is prone to injury in martial arts. When, for example, a frontal position (posture), which is commonly used in karate, is performed correctly, the load on the lumbar spine is minimal. However, when the pelvis is positioned incorrectly in the frontal plane, excessive pulling of the trunk towards the front or to the back may occur, which may cause considerable changes to the shape of lumbar lordosis and, as a result, overloading of the spine. The study proves that if the strength of abdominal muscles in karate practitioners is insufficient, weak stabilisation of the trunk and worsening of lumbar lordosis may occur, which may cause pain in the spine and considerably reduce the spine mobility both within the range of flexion and extension.

Higher values referring to movements of the lumbar spine flexion to the side towards a dominant limb and a non-dominant limb, which were found in the authors' study, may result from the specificity of this sports discipline, e.g. leg techniques performed along a curve (*mawashi-geri*). Kicks at the head level are given the highest score (therefore flexibility of *kumite* practitioners and full mobility of their spine are very important). During a fight, karate practitioners move dynamically in a stepping forward position based on the metatarsal area of foot and often move their feet off the ground [33]. A higher score for leg techniques enabled in competitions made those techniques more dynamic and attractive. [34]. The kicks *yoko-keage*, *yoko-geri*, ura yoko-geri, and *tobi yoko-geri* applied in karate favour an increase in the range of the lumbar spine mobility.

The values of the range of the thoracic spine rotation, which are higher than the standard, may result from the leg techniques performed along a curve (*mawashi-geri*) used in this sports discipline. The study of Sterkowicz and Franchini [5] proved that just this technique is the most effective.

The practice of karate can cause the improvements in posture control. However, there is still a lack of scientific evidence of this fact in the literature and the statement of specific adaptations in the organ of motion resulting from specialised practice (*kata* or *kumite*). The kata practice can lead, according to Filingeri et al. [7], to significant improvement of balance control in a faster and safer way than *kumite*. The practice of *kata* could be approved in the development of new strategies to prevent, e.g. falls in the elderly population. This is a big public health problem and requires adequate, effective and rapid intervention [35-37]. Just adapting the elements of karate technique can help, representing a new approach to this problem [7].

Extreme sports, including combat sports, are associated with high training loads, which are associated with the start-up of all body reserves and may lead to excessive use of the motion organ [38]. Therefore, in addition to evaluating the mobility of the spine, it would be reasonable to undertake a future study to evaluate the level of pain experienced by skilled karate athletes in the context of future spinal injuries in this group of athletes painful spine in the elderly.

CONCLUSIONS

Long-term karate training results in an increased mobility of the spine in karate practitioners compared to their non-training peers. In karate practitioners, lower values in relation to the standard were observed only within the range of extension of the lumbar section and flexion of the cervical and lumbar spine. This indicates the need to introduce specialist exercises to the training to compensate for the deficiencies of the spine mobility, because flexibility may help to prevent injuries.

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