ORIGINAL ARTICLE

The kinematic effects of taekwondo strokes in various conditions the outside environment. Interpretation in the psychological aspect and perspective of application in sport, health-related training and survival abilities

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Manuscript Preparation
E Funds Collection

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Abstract

Background & Study Aim: In traditional taekwondo hand strikes are an important element of the training of athletes. The aim of this work was the knowledge whether a kinematic effects of straight punch depends on a physical conditions of hitting (without physical target and in plastic board) and the lateralisation.

Material & Methods: Five women training taekwondo ITF were analysed. During the tests, from side standing posture (position), they were performing the traditional hand strike without physical target and into a typical plastic "breaking board" that is commonly used for taekwondo competition (in part of dedication of martial art – performance). For the purpose of this research, HML (Human Motion Lab) was used.

Results: The registered maximum speed of the fist, during the execution of a straight punch without a physical target was 7.08 ±0.95 m/s for the right hand and 7.19 ±0.80 m/s for the left hand. While during the board breaking 5.52 ±0.79 m/s for the left hand and 6.12 ±1.02 m/s for the right hand. The factor of preference of left or right side of the body did not contribute to the speed of the straight punch in the taekwondo athletes. Significant differences ($p<0.01$) were seen during the execution of straight punch on different conditions (target and without physical target).

Conclusions: These empirical effects may be associated with the concept of resource sharing, if action has a higher ceiling of difficulty, it is followed by extended reaction time and the mechanism of the speed-accuracy trade off. The results of these studies open up a new perspective on interdisciplinary analysis of taekwondo and other combat sports as a modern means of rehabilitation, therapy and improve the quality of life (including the ability to survive).

Key words: cognitive factor • dynamic balancing • movement analysis • precision • sports psychology • velocity

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Ap jumok jirugi – name of traditional hand strike in taekwondo ITF.

Non conscious process – a mental process occurring outside of and not available to conscious awareness. Usually we focus on only one source of information at the time.

Cognitive schema – An integrated network of knowledge, beliefs, and expectations concerning a particular topic.

Psychological assessment – The measurement and evaluation of abilities, aptitudes, and personality characteristics. The measurement of mental abilities, traits, and processes.

Extreme sports (EFPA) – "extreme form of physical activity are extreme sports, often classified according to the environment in which they are performed (water, land, air), extreme form of physical recreation as well as gainful activity or voluntary service, and all varieties of physical activity that meet at least one classification criterion of the feature associated either with extreme risk of injury or death, or extreme body burden with high level of effort, or extreme coordination difficulty" [31, p. 19, see also 32]

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 [33]

Position – *noun* **1.** the place where a player is standing or playing **2.** the way in which a person's body is arranged [33].

Posture – *noun* the position in which a body is arranged, or the way a person usually holds his or her body when standing [33].

Technique– *noun* a way of performing an action [33].

Technique analysis *noun* same as **biomechanical analysis** [33].

Biomechanical analysis – the use of technical sciences for the analysis of biological systems.

Introduction

Today, the fact that women are involved in activities that once were viewed as typically masculine or extreme, is not surprising anymore. The involvement of women in competitive sports causes them to undertake many extreme challenges. Over time, along with socio-cultural changes the fact that they do boxing, wrestling and far-Eastern martial arts has become a standard, and their sports rivalry brings with it the excitement. The factor of gender in martial arts is also within the scientific interest.

Activity referred to as competitive or extreme is the subject of interdisciplinary research using many modern methods. The psychological analysis of issues regarding extreme sports depends on the individual features of man [1]. In martial arts these challenges may affect every level of bio-psychological operation, from expression of the will to fight, the mastery of emotions (including the desire to avoid confrontation), or the ability to coordinate their actions, depending on the requirements of the situation(e.g. during the fight) to the precision of the individual techniques. What we can see as steps, from the outside as observers (e. g. a straight hand strike) are only the most visible parts of the processes running at different speeds on the level of the nervous system. Pattern-specific neural activation is known, that occurs during the period of preparation for the performance and the performance itself. The changes relate amongst other, to the control of processes of attention, spatial and kinaesthetic stimuli processing and in the period just before and during the implementation of the task [2]. The beliefs and intention are also one of the important elements engaged in forming particular plans. They make up a strong motive for decisions, and for activity choices. In the cognitive and behavioural perspective in every behaviour of an individual, regardless of the fact if it is about maintaining health, getting used to stress or dealing with sports challenge they combine cognitive, emotional and motivational elements. As a result of taekwondo training technical and motor skills grow, that contribute to the optimization of in the psycho-medical aspect [3]. This fact reveals a giant field of inquiry, which brings together and penetrates issues in the fields of biomechanics and psychology.

Research on the physical functioning, strength and speed in sport, confirms the significant differences in the physical capabilities of women and men [4]. While differences in variables related to most aspects of cognitive functioning and coordination proved to be less clear [5].

It is well known that the correct sports technique must be compatible with the principles of biomechanics of the human body. Over the years, preparation of martial arts athletes, has changed. This was often due to scientific analysis as well as proposals backed up by research. Such development caused the need to tailor training and curricula to the new rules [6, 7].

In traditional taekwondo (International Taekwondo Federation) sports rivalry is based on five elements: formal patterns, arranged combat, sparring, special techniques and force tests [8]. During the performance of formal patterns, the athlete concentrates on strikes that have no physical target, while during the force tests he or she can use the same techniques to destroy physical targets. Here the question arises as to whether these strikes differ from each other?

In this variation of taekwondo straight hand strikes are an important element of athletes training. In sparring, they are the most commonly used form of attack and counter-attack [6], and in the competition of force tests are one of the important techniques affecting victory [9]. Therefore, the ability of proper teaching and the use of this kind of strikes, is one of the basic skills of athletes of this martial art.

In taekwondo, most attention is given to kicks [10-15]. The analysis of a straight hand strike in taekwondo, can only be found in few works. Stull and Barham [16, 17] compared achieved values of speed and strength from shotokan karate, kempo, kung-fu, and taekwondo, during the execution of the straight hand strike. Pieter et. al [18] have designated speed and impact force of a straight hand strike and kicks: side, round house. They suggested that quantitative studies are needed to better understand these techniques. It is noted that the moment of obtaining the maximum speed of the fist and its impact on the end result [19]. Researchers, Rybicki el. al [20] found that the time of a straight sports hand strike in taekwondo is between 30ms to 50ms.

The aim of this work was the knowledge whether a kinematic effects of straight punch depends on

a physical conditions of hitting (without physical target and in plastic board) and the lateralisation. This is a step in the direction of a deeper examination of the biomechanical and psychological determinants of strikes in martial arts.

Material and methods

Subject

Five women training taekwondo ITF (International Taekwon-do Federation) were analysed (age: 20.8 ±3.4 years; body mass: 57.2 ±7.0 kg; height: 167.2 ±6.9 cm). During the tests, from side standing posture (according to the terminology of taekwondo: *niunja sogi palmok debi maki*), they were performing the traditional hand strike physical target (into the air) and into a typical plastic "breaking board" that is commonly used for competition. The strikes were performed 3 times into each target, using both the right and left hand. In total 60 attempts were registered.

The Human Subjects Research Committee of the University scrutinized and approved the test protocol as meeting the criteria of Ethical Conduct for Research Involving Humans. All subjects in the study were informed of the testing procedures and voluntarily participated in the data collection.

Protocol

For the purpose of this research motion analysis lab HML (Human Motion Lab, Poland) was used. The facility included ten NIR Vicon MX-T40 (Vicon, USA) cameras with the resolution of 4 MP (2352x1728 px) as well as 10-bit grayscale. The system allows to capture up to 370 frames per second at full resolution. The measurement space has a cylindrical shape of the ellipsoid height with the height of 3 m and on the basis of the axes 6.47 m, 4.2 m. Indicators registered structure of spatial-temporal motion marker placed on the fist, specifying its speed changes as a function of time. Using this method, resultant maximum speed of the fist was recorded.

Statistical analysis

For each indicator, mean value as well as standard deviation were calculated. Normality of the distribution was verified by Shapiro-Wilk test. The differences between the compared groups were assessed on the basis of t-test. Statistical significance was adopted at the level of $p<0.01$. All calculations were made using SPSS Statistics 20.0 (IBM, USA).

Results

The average maximum speed of fists during the execution of the straight hand strike without physical target for women is 7.08 ±0.95 m/s for the left hand and 7.19 ±0.80 m/s for the right hand. There were no statistically significant differences in maximum speed of the strike between the left and right hand (Table 1). Figure 1 shows a sample graph (one female taekwondo athlete) of the changes in the speed of fists during the same strike, differing in circumstances.

Discussion

In karate athletes (male) values registered were between 5.7 to 9.8 m/s [21]. By comparing the obtained value of speed to the speed of the other strikes (performed by men) for example, side kick: 5.20 to 6.87 m/s [22]; spinning back kick: 5.95 to 8.35 m/s [23], we can say in jargon that *ap jumok jirugi* belongs to simple strokes with high speed (in fact experienced taekwondo athletes can perform this strike very fast).

Obtained data can inform us about the relatively uniform development of both left and right hand in tested athletes. It is justification for the methodology of training. During the

Table 1. Speed of fist-straight traditional strike (total 60) by taekwondo female athletes (n = 5) in different circumstances.

Hand	Circumstances hand strike						*p*-value
	without physical target (into the air)			into the plastic "breaking board"			
	mean	SD	range	mean	SD	range	
left	7.08	0.95	5.89 ÷ 9.42	5.52	0.79	3.64 ÷ 6.68	0.000
right	7.19	0.80	5.80 ÷ 8.88	6.12	1.02	4.75 ÷ 7.85	0.005
p-value	0.79			0.81			

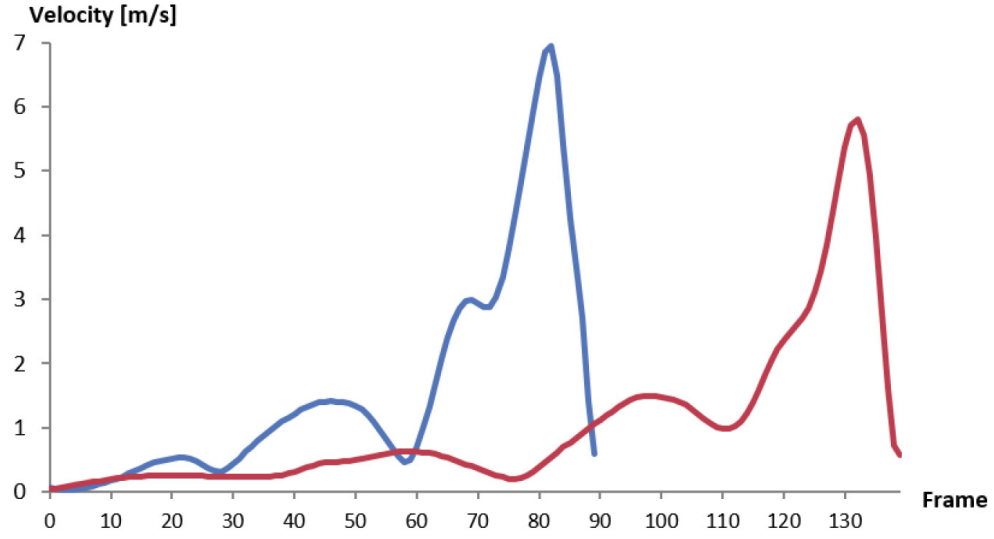

Figure 1. Sample graph (individual female athlete) of speed changes during the traditional hand strike, depending on the target of the strike (blue line-strike without physical target, red line-strike into the plastic "breaking board").

training of traditional variety of taekwondo, usually drills for both sides are performed. These exercises are woven into the very important part of the training, that is, the systematic improvement of the complex sequences of forms. This result highlights the two important aspects. The first dimension is health. Formal taekwondo exercises activate both symmetrical parts of the body (through alternating repetition exercises limbs and the use of bilateral turnover). Second, utilitarian - both limbs can be used with a similar probability of success in self-defence.

Researchers working on the grounds of physical activity psychology, indicate that the component of rhythm and repeatability of movement, in which the same motion is repeated constantly, promotes the growth of mental training concentration skills and sense of satisfaction [24]. Exercise that requires coordination activates the cerebellum, which is located at the back of the brain and enhances thinking, cognitive flexibility and processing speed. In the past few decades, psychologists and medical professionals have been exploring and researching what they've termed the mind-body connection. In fact, a whole new branch of medicine has emerged that focuses on the interaction of the brain, mind and body. There have been reports indicating that improvement of skills and efficiency of the non-dominant limb is accompanied by beneficial changes in certain brain structures [25]. Word scientific literature and martial arts practice corroborated with increasing amount of scientific research shows that an interdisciplinary, thoughtful view on the problems connected with the improvement of an individual's psychophysical functioning (sense of positive health) multiplies and strengthens effects [26].

In the attempt of board breaking, a clear decrease in maximum speed was registered ($p<0.01$). Therefore, on the basis of data collected (Table 1), we can assume that the revision of the research procedure that implemented a physical target, influences upper limb kinematics during the execution of the *ap jumok jirugi*. Female athletes, during the execution of this strike, without a designated physical target, achieved higher maximum speed and shorter execution time (Figure 1). Such action is in accordance with the concept of resource sharing [27]. It was noted that when the activity has a higher ceiling of difficulty, it is followed by the extension of reaction time. Our system is "paying" with prolonged time required for the execution of complex, multidimensional tasks (something at the expense of something else). This can also be associated with the speed-accuracy trade off mechanism [28]. It shows that the fastest strikes bring problems with control. Therefore, for the athletes that indeed it is important to accurately hit the target, in order to fully control the motion, they aren't fully using the maximum energy that they are able to generate. Similar findings were obtained in other studies [29, 30].

In the available scientific literature, there is little biomechanical research of women who regularly train in combat sports. We hope that this work will partially fill the gap. The considerations contained in it, are part of research aimed at understanding of the role of individual factors that influence strike kinematics and the next step to a more complete knowledge of speed-accuracy relation compromise mechanism, based on martial arts analysis, taking into account biomechanics and psychology. These results and considerations can be a data set for comparison to other researchers, and can set the way for further exploration of interdisciplinary nature.

Conclusions

On the basis of the conducted research, we can observe that during a straight punch performed by the examined taekwondo competitors: no statistically valid differences in the maximum velocity of a straight punch between the left and right fist have been observed; the intentionally indicated physical target of a punch influenced on the movement kinematics; when punching a "board" the competitors reached lower maximum velocity and longer movement time than in the case of a punch without a physical target.

These empirical effects may be associated with the concept of resource sharing, if action has a higher ceiling of difficulty, it is followed by extended reaction time and the mechanism of the speed-accuracy trade off. The results of these studies open up a new perspective on interdisciplinary analysis of taekwondo and other combat sports as a modern means of rehabilitation, therapy and improve the quality of life (including the ability to survive).

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