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Studies of kicking of three targets – does sex differentiate the velocity of the taekwondo front kick?

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Data Interpretation
E Manuscript Preparation
F Literature Search
G Funds Collection

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abstract

Background: The aim of the research was to obtain knowledge concerning the impact of selected external determinants (kick target) and internal determinants (sex) on the movement kinematics during the performance of a front kick by taekwon-do practitioners.

Material and methods: The analysis was performed on 8 men (18.3 ±1.7 years old) and 6 women (19.8 ±3.8 years old) practising taekwon-do. During research they performed front kicks into the air, at a table tennis ball hanging on a line and a training target (shield). A laboratory was used for analysis of the movement.

Results: The mean maximum velocity of a kick into the air was registered (10.78 ±1.32 m/s for men and 8.51 ±1.50 m/s for women), at the target (9.98 ±1.40 m/s for men; 8.28 ±1.59 m/s for women) and at a ball (9.63 ±0.94 m/s for men; 7.73 ±2.01 m/s for women).

Conclusions: The change of external conditions in the three examined cases has an impact on the front kick kinematics. Significant differences between the maximum movement velocities during the kicks performed in the case of women and men were found.

Key words: kicking velocity, precision, dynamic balancing, taekwon-do, movement analysis, kicks kinematics, intentional goal.

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INTRODUCTION

Velocity and accuracy belong to very important factors that allow winning in taekwon-do. We are aware that a certain part of the decision-making process happens beyond our conscious control or, in a way, it is not completely conscious [1].

There are reasons to think that the features of an object (or a lack thereof) may directly change the kinematics of a kick [2]. However, can sex cause dissimilarity in this respect? There is a dearth of studies examining kicks at different targets used in taekwon-do (TKD) in the case woman and man. The differences within the variables connected with the majority of the aspects of cognitive functioning and movement coordination between women and men appear to be ambiguous [3]. The character of the requirements towards the motor activity depending on the sports discipline conditions the differences between women and men. However, most previous research on kicking techniques has focussed on male taekwon-do athletes, and little research has been conducted on female ones [4–6]. Although there exist clear differences in the skeletal structure, muscle power, and flexibility between female and male athletes, the characteristics of kicking techniques in female and male martial arts athletes have not been clarified yet. There are still many questions about the speed and force of kicks. Few studies have rigorously addressed these differences. Busko et al. described these results in their studies [7]. They also found that the force of a straight rear-hand punch was greater than the force of a lead-hand punch among male and female boxers. The force of kick delivered with a rear leg was greater compared to the lead leg among male and female taekwon-do athletes. Significant gender differences were noticed in the force in both types of kicks [7]. The technical level of women's taekwon-do is rising every year. Consequently, there is great demand for improving kicking techniques to enable faster performance.

Depending on the concept of exercises, the movements will be performed with a different purpose. In health or educational training, kicks will be aimed at "the air" or different objects (shield, boxing sack, etc.). In sport fight training or self-defence training, we will rather concentrate on aiming at opponents. Each of these aims will require a different type of accuracy, strength and velocity. It is connected with the ability to control and manage movement mechanisms and numerous interactions between the features of a particular person, the performed task and environment [8]. We also know that different situational determinants are connected with different movement kinematics [9]. The velocity measurements indicate significant differences in the case of the same kicks at different targets. Studies of kicking at targets reveal that kick velocity decreases before target impact [10].

The aim of the research was to obtain knowledge concerning the impact of selected external determinants (kicking target) and internal ones (sex) on movement kinematics during the performance of a front kick by taekwon-do practitioners. The assessment was performed on the basis of the obtained values of changes in foot velocity during the performance of a kick and the practitioners' sex. The following questions have been asked:

1. What is the movement velocity during the performance of a front kick, depending on a target?
2. Does gender (sex) determine the differences in movement kinematics during a front kick?

MATERIAL AND METHODS

Subjects

The analysis was performed on 8 men (age: 18.3 ±1.7 years; body mass: 70.4 ±6.0 kg; height: 176.2 ±3.0 cm) and 6 women (age: 19.8 ±3.8 years; body mass: 57.7 ±6.5 kg, height: 167.7 ±6.4 cm) practising ITF taekwon-do (International Taekwon-do Federation athletes).

The contestants (the competitors who were subjected to the presented research) declared that they train regularly between 3–5 times a week. The group consisted of champions of Europe and Poland, as well as people who have been training for at least 4 years. They possessed degrees of skills from 1 kup to 3 dan.

The experimental task was to execute a kicking motion. Each participant was asked to warm up. All the registered kicks were performed by the trailing leg. While conducting the measurements, the contestants did not receive any signal to commence. The only piece of information was to execute the blows as quickly and as best as they could. The height and distance from the target to be hit were adjusted to the height of the contestant and to his/her preferences.

During research they performed front left and right kicks in a lateral standing position (in taekwon-do: niunja sogi palmok debi maki): into the air, without a physical target (air), at a table tennis ball hanging on a line (ball) and at a training shield. Each kick was performed 3 times at each target. Altogether 192 attempts for men and 144 attempts for women 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

A laboratory named HML (Human Motion Lab) was used for the analysis of movement. It was composed of 10 cameras NIR Vicon MX-T40 of the resolution 4 MP (2352 x 1728 px) 10-bits greyscale. The system allows intercepting up to 370 fps in a full resolution. The movement of markers located on a foot, specifying the changes of velocity of a foot towards the axis X, Y, Z, was registered. The maximum resultant velocities were indicated in this way.

Statistical analysis

For all registered maximum velocities the mean and standard deviation were indicated (the particular measurements were added and divided by the number of blows, separately for the gender and target). The normality of the distribution was checked with the Shapiro-Wilk's test and the Levene's test was used to check the homogeneity of variance. A comparison of the variance of the dependent variable was conducted on the basis of two factors of a qualitative nature, namely gender type and the type of target which the blows were aimed at. The differences between comparable groups were assessed by ANOVA, and the statistical significance was assumed at the level of $p < 0.05$. Additionally, analysis using the post-hoc test with Bonferroni's correction was conducted. The η^2 coefficient was calculated with the aim of highlighting the

proportion of variability associated with the analysed factor (gender types) with relation to the total variability of the registered velocities of the motion while kicking. The Λ coefficient (measurement of the percentage variance in dependent variables) has been applied in order to check whether differences exist between the groups for the defined combinations of dependent variables All measurements were performed with the use of Statistica 12.

RESULTS

Figure 1 illustrates the acquired velocities with regard to the gender types as defined by the target (object or lack thereof) of the kick. In Table 1 the results of two-factor analysis of variance (gender type/target) have been presented. Table 2 presents descriptive statistics of mean velocities during the performance of a front kick for women and man depending on the target.

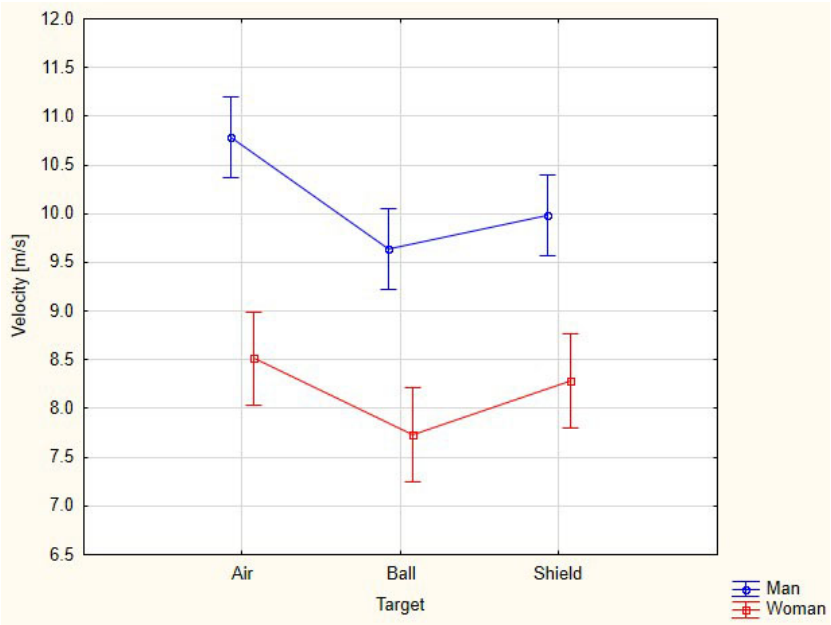

Fig. 1. Graphic illustration of the acquired velocity with regard to gender in terms of the kicking target F(2.246) = 0.793; p = 0.454. Vertical bars signify 0.95 confidence intervals

Table 1. Two-factor results (gender type/target) analysis of the variations

	F	p	η^2	Λ	M
Target	8.93	0.00	0.07	17.87	0.97
Gender	110.49	0.00	0.31	110.49	1.00
Target × gender	0.79	0.45	0.00	1.59	0.18

F – result of analysis of variance, p – statistical significance, η^2 – measure of the effect size (it is the proportion of variance accounted for by some effect), Λ – lambda is a measure of the percentage variance in dependent variables not explained by differences in levels of the independent variable, M – observed power (α = 0.05).

Table 2. Descriptive statistics of mean velocities during the performance of a front kick

Factor			Min [m/s]	Max [m/s]	Average [m/s]	SD	-95.00%	+95.00%
Target	Air		6.36	13.44	9.81	1.79	9.42	10.20
	Shield		4.87	12.40	8.82	1.76	8.44	9.20
	Ball		5.13	13.71	9.25	1.70	8.88	9.62
Target×gender	Air	Male	8.65	13.44	10.78	1.322	10.39	11.16
	Air	Female	6.36	12.99	8.51	1.501	8.00	9.02
	Shield	Male	8.07	11.77	9.63	0.937	9.36	9.90
	Shield	Female	4.87	11.13	7.73	2.014	7.05	8.41
	Ball	Male	7.26	12.40	9.98	1.405	9.58	10.39
	Ball	Female	5.13	13.71	8.28	1.592	7.74	8.82

DISCUSSION

As assumed, the sex difference between the examined groups was seen. The obtained values of maximum velocities of a kick were higher in the case of men than women ($F = 110.49$; $p < 0.01$). The mean velocity of motion while executing a foot technique (kicking) is systematically higher for men than for women (Fig. 1) (Table 2).

Analysis of variance results revealed a significant difference between movement velocities during kicks between males and females, in the three variants (shield, ball and without physical target) ($p < 0.01$) (Table 1). The determined effect size for gender, based on the explained variance, amounted to $\eta^2 = 0.31$, which, according to guidelines for assessing values, shows large size effect of gender [20]. The observed power for the gender factor amounts to $M = 1$, while for the target factor $M = 0.97$ (Table 1).

The collected data reveal that the change of external conditions in the three discussed cases influenced the movement velocity during the performance of a front kick. There are substantial premises to think that such activities correspond with the concept of reserves distribution, described in cognitive psychology [12]. This concept talks about the selectiveness of concentration on a particular task in the categories of dividing energetic reserves of the nervous system, as under the rule “something is done at the cost of something else”. There are reports showing that the efficiency of the information selection process depends on the target of the objects processing in the field of attention [13]. We may assume that in a situation when it is important to be accurate with the target, in order to fully control the movement, the performers do not fully use the maximum energy they can obtain. On the basis of the above, we may assume that an increase in precision negatively influences velocity. This mechanism is known as the speed-accuracy trade-off [8]. It assumes that the fastest kicks potentially introduce disorders in control.

The results of research may indicate that sex has no impact on the kinematic effect of a target. The obtained results correspond with other research presented in literature that indicates that the skills requiring fast activity of the nervous system were similar in the case of women and men [14]. Despite significant limitations of energetic possibilities in women, there are no proved differences with respect to men within creating the patterns of movement and their use in complex movement tasks.

In a self-defence situation, we face the dilemma if to hit once, precisely, according to the rule of one possibility [15], or fast with the risk of inaccuracy. Such a dilemma may have a key meaning in the situations that are referred to as borderline, when there is a lot to lose and in which the method of undertaking an activity may mean the difference between life and death during confrontation.

Sex differentiation within the motor skills has already been a subject of research [6]; however, in the accessible literature there is still not much of biomechanics research concerning the measurements of women and the research concerning the mechanism of compromise in the relation: velocity–precision in martial arts. We hope that this paper will partially fill this gap.

The considerations that are included herein belong to the stage of longitudinal research leading towards a deeper understanding of the role of certain factors that influence the kinematics of kicks. In connection with the research indicating a possibility of the existence of differences with respect to the feeling of efficiency depending on gender [16], this factor will have to be included in further research on the determinants of the mechanism of velocity–precision in martial arts. This study is part of long-term interdisciplinary research [17–19]. The possibility of research concentration on widely understood optimization of man's functioning makes a vital common plane connecting all these differentiated fields of competence (sport science, biomechanics, health psychology).

Studies of kicking at targets reveal that kick velocity decreases before target impact [10]. In this study, emphasis was placed on how gender influences the kick velocity. In future studies, we intend to measure velocity and forces while women and men hit an actual target to account for modifications in the motor strategy in preparation for the impact with the target. These results can be useful to a martial arts practitioner who is in training, as well as to instructors who teach martial arts.

There are many items describing gender differences; for example, Busko et al. found significant gender differences in the force in two types of kicks [7]. The potential sources of differences in kicking velocity (like gender) in taekwon-do still are the focus of many martial arts discussions [21, 22].

The results and considerations presented in this work may contain material for comparisons for other researchers and may indicate the path for further research of an interdisciplinary character.

CONCLUSIONS

This study shows a statistically significant difference in velocity generated by woman and man during a front kick in taekwon-do. The results showed that the average foot velocities in female athletes were significantly lower than those in male athletes ($p < 0.05$). Summarizing the above, we can say that in the presented research found basis to think that gender has an impact on the velocity during a front kick in taekwon-do. These findings have the potential to assist athletes and coaches in the learning and teaching the front kick.

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