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THE INFLUENCE OF BODY POSITION ON THE SPEED OF A SIDE KICK IN KICKBOXING

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Abstract. *Kickboxing is a combat sport where two types of fights occur: light-contact and full-contact. There is no limitation on the strength of kicks and punches in the latter type. In martial arts, athletes try to hit an opponent with as much speed and power as. The position of the upper body is indicated as the most important factor directly influencing the performance of the kicks. The aim of the research: to determine the effect of a change in the position of the upper body of a 14-16-year-old kickboxer on the time of execution of the side kick with the foot placed in front and the ground reaction force in the place, moving forward and in the counterattack, determining the time of the side kick and the ground reaction force of the take-off foot in three different upper body positions to give the execution time of each type of side kick and the ground reaction force of the take-off foot. The fastest side kick with the forward foot in place and moving forward will be in the upper body position 45° to the vertical axis, but performing side kick with the forward foot in counterattack and side kick moving forward from the position of the upper body 90˚ against the vertical axis was partially proved.*
Keywords: *force platform, kickboxing, side kick, support reaction force, upper body position.*

Introduction

Kickboxing is a combat sport where two types of fights occur: light-contact and full-contact. There is no limitation on the strength of kicks and punches in the latter type (Ambroży et al, 2020). In martial arts, athletes try to hit an opponent with as much speed and power as possible (Gulledge & Dapena, 2008). The literature on martial arts states that the performance of a kick depends on a number of factors that affect the performance of the kick, such as distance, height of the target, type of technique, technical level of the athlete, gender, and weight category. The position of the upper body position is indicated as the most

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important factor directly influencing the performance of the kicks (Boyat, Singh & Sandhu, 2017; Estevan, Falco & Jandacka, 2011).

The aim of the research: to determine the effect of a change in the position of the upper body of a 14–16-year-old kickboxer on the time of execution of the side kick with the foot placed in front and the ground reaction force in the place, moving forward and in the counterattack.

The time of the side kick performance was registered using "BTS SMART DX" infrared motion capture camera from the moment when the kicking foot begins to leave the floor until the foot reaches the target. All attempts were entered in the record.

The dynamometry method was arranged simultaneously with the cinematography method. As part of the experiment, the dynamometry method was implemented using BTS p-6000 force platforms. Using force platforms, data was collected on the force of the kicking foot, and, using the platform, it was also possible to determine if the position of the upper body influenced the kick. To obtain exact data on the force of the kick, the athlete should place the anchor leg on a platform, and it is important to ensure that the anchor foot is placed fully on one platform and also takes off the same platform. The place of landing after the take-off is not important.

Kicks in kickboxing

Kicks in kickboxing are very specific. There are several types of kicks: shaking, stabbing, pushing, pressing and kicking in a jump. Likewise, it should be born in mind that during a combat it is important not only to perform strong and precise kicks, but also to return the foot to the initial position to avoid staying in an unstable position and to assume a comfortable position for defense or for preparing the next attack (Falco, Estevan & Vieten, 2011). Kicks can be made both with the right and the left foot, and almost all kicks can be made standing on the spot, approaching the adversary with a step, in a hop, or in a jump. Most kicks can be performed in several basic variations. First, every kick can be made both with the front and with the back foot. In some cases, it has such a significant impact on the kick performance technique that two completely different kicks seem to be performed, yet they have the same name. second, any hit can be made from the spot, after a step, or with a hop. Most kicks are also used in a jump, but this maneuver has a noticeable difference from performing a kick with a support and has multiple peculiarities in almost all its phases. Third, kicks differ depending on the level of use. Usually, all kicks can be made on the three main levels: high, medium, and low.

Kicks in combat sports have various performance variants and tasks depending on the combat situation, which differ in various characteristics. Mastering the kick technique takes place in multiple stages, and it is a careful

process where the development of technical and physical qualities takes place gradually, harmoniously complementing one another. A kick can be performed on the spot turning the body by 180° or by 360° and even by more than 360°, in a jump and in various combinations (Grassie, 2017). All kicks can be performed in three main directions: forward, backward, and sideways. There are only three basic kicks in these directions: forward straight (front kick), backward straight (back kick), and sideways straight (side kick). They are called basic kicks. Various other kicks, which are derived from the basic kicks are called derivatives (front hook, sideways hook, back hook). The exception is a downward kick with a straight leg from the upper position, which is a basic movement but does not form the basis for any derived kick.

A side kick is quite often used during combat; it is employed for long-range attacks. A side kick using the foot placed in front can be used for starting a combat, starting and finishing an attack, meeting and stopping the opponent, keeping the opponent at a certain distance, employing it in combinations and series of kicks. After punches, side kicks have the highest efficiency coefficient of all attacks in kickboxing (Ouergui, Hssin, Franchini, Gmada & Bouhlel, 2013). Many athletes use side kicks during combat more than any other kick because it carries a lower risk of injury than lead and hook kick techniques. Also, the kick's half-facing position offers less information on the planned attack to the opponent than the facing position. (Lee, Lee & Han, 2008).

A side kick is a power kick. The group of power kicks includes kicks where in the preparation stage an active strengthening of the upper leg is combined with a passive lower leg. A classical power kick has the lower leg fixed in the finishing stage. The kick formula from the preparation stage is as follows: active upper leg and passive lower leg. The involvement of the lower limb in the kick's motion mechanism takes place in three kinematic chains linking upper leg – lower leg – foot. When a kickboxer kicks using good technique, the effort is transferred from the hip to the upper leg and then to the lower leg and the foot, facilitating a continuous and gradual increase in power and speed in each link of the kinematic chain, from the first stage of the kick to the completion, providing power in the kick (Belykh & Oleynik, 2019).

Biomechanical studies on martial arts showed an interest in the way the force that impacts on the platform (support reaction force) influences the time of the kick performance. Studies show that, the higher the athlete's support reaction force, the short the time of performing the kick. It also seems that there is a positive correlation between the support reaction force and the speed of the kick segment. Support reaction force during a kick has a wide range, from 382 to 9015 N. The reason for this range is in different methods of data collection, variations in the types of sensors, athletes' peculiarities, kick or training methods, and the target's inertia or elasticity. The heavier and stronger the target, such as a heavy boxing bag or a fixed surface covered with polyester, the higher the kick's

support reaction force generated by the athlete. In all, kicks at the chest level (middle range) developed a higher kick support reaction force than kicks at the head level (upper range). Meanwhile, for high-level athletes, the height of the target does not influence the support reaction force. Overall, a higher body mass creates a higher kick support reaction force. Still, these correlations are more often found in lower-level athletes (Jandačka, Estevan, Janura & Falco, 2013). Likewise, the difference in the support reaction force of the kick depends on the athlete's weight. Statistically significant correlations between these parameters show the athlete's ability to increase the force of the kick due to a higher body mass (Pędzich, Mastalerz & Urbanik, 2006).

All the above factors lead to considering ways of performing kicks with maximum results, reaching the target quickly and precisely, and of joining and optimising the activities of the kinematic chain according to the condition of each part of the body, and for which movements and trajectories the force and speed power are to be developed.

Methodology

A study group (sample) was developed for the study using the following criteria: age, gender, and training experience. 5 male athletes from the sport club Chin-Goo aged 14-16 with the experience of training in kickboxing for at least 5 years were selected.

The experiment participants were asked to take the combat position they found the most comfortable to achieve the greatest possible foot speed during the kick. This shows the need to study the ability to perform the kick depending on the position of the upper body. The experiment participants performed three side kicks in three positions of the upper body, at the angles of 0°, 45°, 90°, making in all nine kicks:

1. side kick with the foot positioned in front from the standing position;
2. side kick with the foot positioned in front moving forward;
3. side kick with the foot positioned in front in a counterattack.

The kick time was registered using a "BTS SMART DX" infrared motion capture camera from the moment when the kicking foot began to leave the floor to the moment it touched the target. All the kicks were included in the protocol.

The participants warmed up for 30 minutes before the experiment in the gym under the coach's supervision. After the warm-up, the test was done in the Latvian Academy of Sport Education (LASE) sport science research laboratory. All athletes one after the other performed three side kicks in three positions of the upper body at the angles of 0°, 45° and 90° to the vertical.

For SMART DX system to register the athlete's movements, the athletes had 10 reflecting straps attached. One reflector was attached to vertebra C7 and to the tailbone. Pairs of two reflectors were attached to the shoulders, to the upper leg

bones, knee joints, and sides of the ankles. The distance from the athlete to the target depends on the type of kick and the athlete. To make a straight kick forward from the standing position before the kick, each athlete measured the distance by straightening the kicking leg to the side kick position so that the foot would touch the target. The distance to the target for the side kick with the foot put forward and in motion and for the side kick with the front foot in the counterattack was measured as follows: the athlete would stand at a distance from the target with the front foot and then would make a small step backwards, putting the front foot next to the back foot and making a small backward step with the front foot.

The dynamometry method was applied to the experiment synchronously with the cinematography method. As part of the experiment, BTS p-6000 force platforms were used for dynamometry. Using force platforms, data about the take-off force of the leg were obtained, and it was also possible to determine whether the position of the upper body influenced the foot take-off. To obtain exact data on the force of the take-off foot. To obtain precise data on the force of the take-off foot, the athlete had to stand with the support foot on the platform, and it is important to ensure that the support foot would be placed fully on the platform only and would take off the same platform. After the take off, the place of landing is unimportant.

The data obtained at the laboratory were processed using mathematical-statistical methods to verify their statistical credibility. Subsequently, the data were compared and analysed to determine if there are correlations between the foot speed in performing a side kick and the upper body positions at 0°, 45°, and 90°.

Research results

The Figure 1 shows the average maximum speed of the side kick from the standing position, moving forward and in counterattack in three positions of the upper body.

The average maximum speed of the participants' side kick with the front foot with the upper body position at 0° is 5.11 ± 0.03 m/s, at 45° the result is 5.20 ± 0.04 m/s, and at 90° the result is 5.39 ± 0.04 m/s. In moving forward with the upper body position at 0° to the vertical the result is 4.82 ± 0.05 m/s, at 45° it is 5.21 ± 0.05 m/s, and at 90° it is 5.21 ± 0.05 m/s. The participants in the experiment showed the average maximum speed of the side kick moving forward with the upper body at 0° of 3.95 ± 0.04 m/s, at 45° of 3.83 ± 0.04 s and at 90° of 3.72 ± 0.04 m/s (Fig. 1).

The highest speed of all types of the kicks was registered in standing position when the athlete stay on the place and execute side kick with concentration on the speed and power. A little less speed we can see in kick moving forward, but lowest average speed performing kick in counterattack.

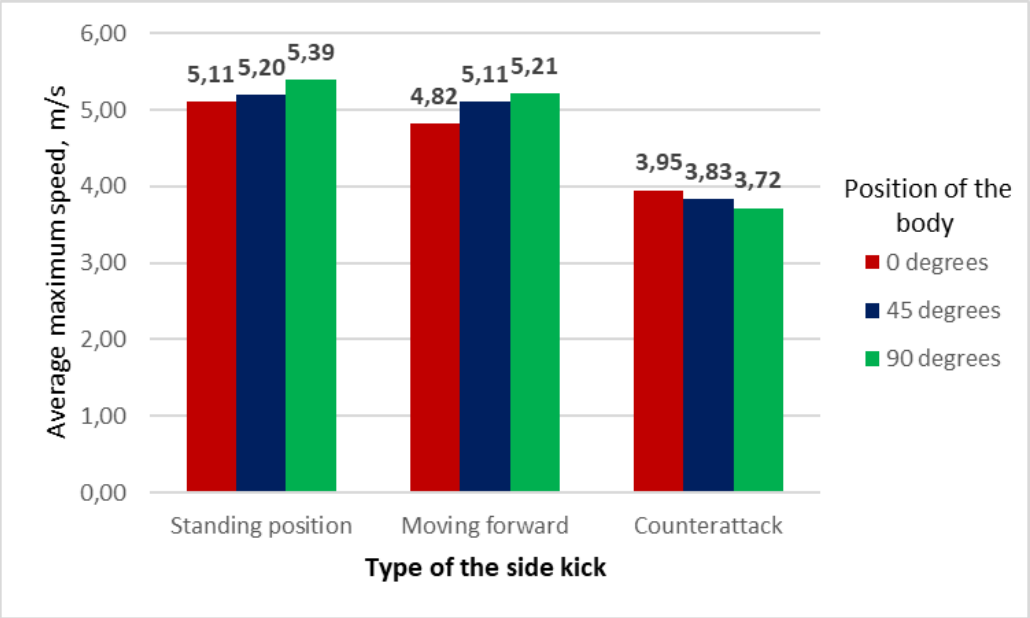

Figure 1 ***Average maximum speed of the side kick from the standing position, moving forward and in counterattack with the upper body in three angle positions, m/s***

Performing kick on the place and moving forward, the same tendency for the speed of the kick to change is observed. Although the speed differs little, the speed increases with a greater tilt of the body back. Therefore, if an athlete wants to perform a kick with greater speed, then he needs to tilt his body back more.

The participants' average performance time of the different types of side kicks with the front leg is shown in the Figure 2.

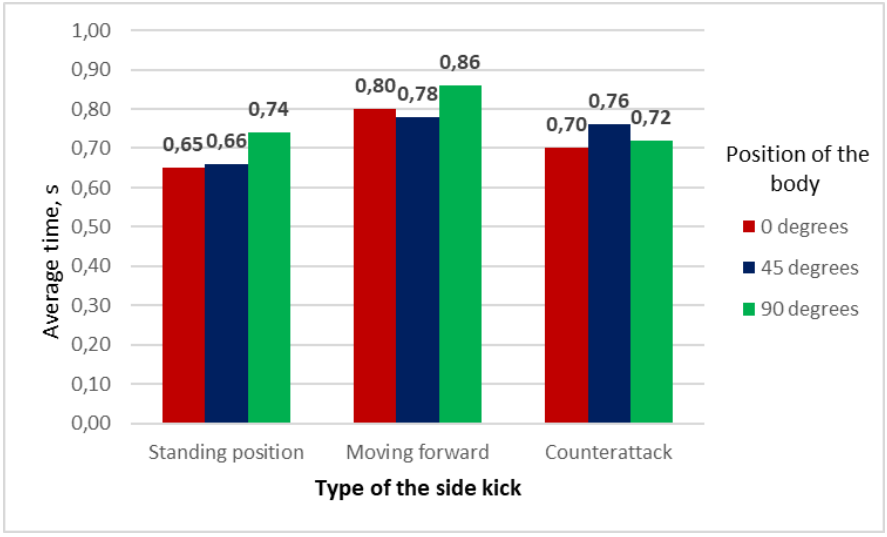

Figure 2 ***Average time of the side kick from the standing position, moving forward and in counterattack with the upper body in three angle positions, s***

In the standing position with the upper body set at 0° against the vertical showed the result of 0.65 ± 0.02 s, at 45° the result was 0.66 ± 0.04 s, and at 90° it was 0.74 ± 0.02 s. In movement when the upper body was set at the angle of 0° to the vertical was 0.80 ± 0.02 s, at 45° it was 0.78 ± 0.01 s and at 90° it was 0.86 ± 0.02 s. The participants' average time of performing the side kick with the front leg in counterattack when the upper body was set at the angle of 0° to the vertical was 0.70 ± 0.01 s, at 45° it was 0.76 ± 0.01 s, and at 90° it was 0.72 ± 0.01 s (Fig. 2).

The shortest time for performing the side kick is observed when kick on the place, since the athlete tries to make the kick as quickly as possible and nothing interferes with him. Comparing the performance time for a side kick with the upper body positions at 0° and 45° to the vertical, no statistically significant differences were found ($\alpha < 0{,}05$). Performance time for a side kick from the standing position with the upper body set at 0° and 90°, statistically significant difference was found. Statistically significant difference in the average time of performing a side kick was found between the cases when the upper body was set at 45° and 90° to the vertical. When the upper body is at 45° to the vertical axis, the shortest time for the side kick is when moving forward, but it takes the longest average time when the upper body is set at 90° to the vertical. The shortest time the upper body positions at 0° for the side kick is when making a counterattack, but it takes the longest average time when the upper body is set at 45° to the vertical.

The participants' average support force for performing different types of the side kick with the front leg indicates the repulsion force of the supporting leg and thereby affects the speed and timing of the kick (Fig. 3).

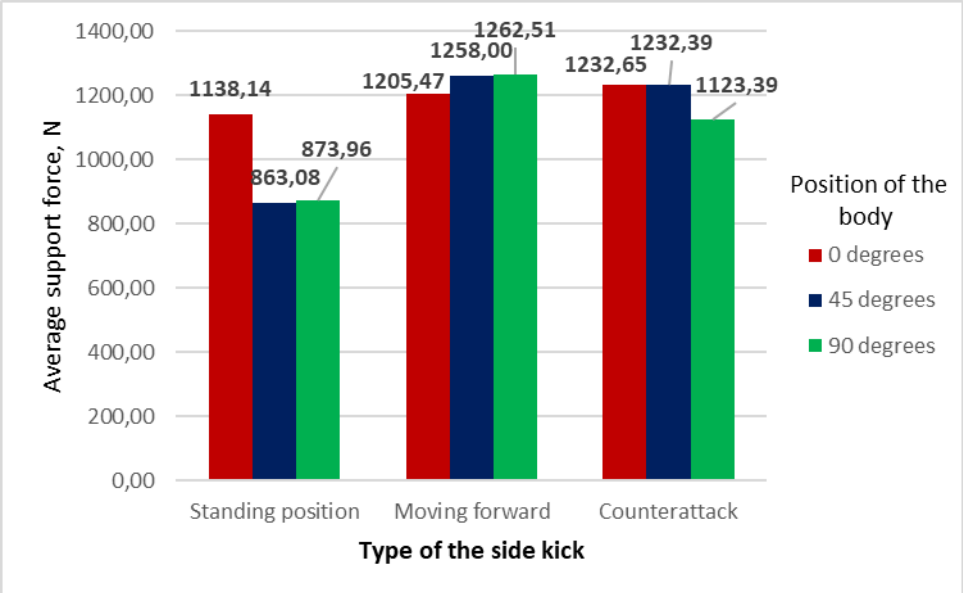

Figure 3 ***Average support force of the side kick from the standing position, moving forward and in counterattack with the upper body in three angle positions, N***

The participants' average support force in the standing position when the upper body was set at the angle of 0° to the vertical was 1138.14 ± 14.98 N, at 45° it was 863.08 ± 17.30 N, and at 90° it was 873.96 ± 23.25 N. Performing the side kick with the front leg in a movement when the upper body was set at the angle of 0° to the vertical was 1205.14 ± 17.30 N, at 45° it was 1258.00 ± 23.74 N and at 90° it was 1262.51 ± 15.40 N. But in counterattack when the upper body was set at the angle of 0° to the vertical was 1232.65 ± 23.25 N, at 45° it was 1232.39 ± 17.90 N, and at 90° it was 1123.39 ± 22.39 N.

When the upper body is at 0° to the vertical axis, the greatest support force for the side kick is when performing it in the standing position, but the smallest value of support force was registered when the upper body is set at 45° and 90^0 to the vertical. Performing the side kick with the front leg in movement the greatest support force for the side kick are when the upper body is set at 45° and 90° to the vertical. The greatest support force for the side kick in counterattack are when the upper body is at 0° and 45° to the vertical axis, but the smallest value of support force was registered when the upper body is set at 90° to the vertical.

Table 1 ***Experimental results for the side kick speed, performance speed and support reaction force***

	Side kick from the standing position			**Side kick while moving forward**			**Side kick in counterattack**		
Upper body position	**0°**	**45°**	**90°**	**0°**	**45°**	**90°**	**0°**	**45°**	**90°**
Kick speed, m/s	5,11	5,20	5,39	4,82	5,11	5,21	3,95	3,83	3,72
Performance time, s	0,65	0,66	0,74	0,80	0,78	0,86	0,70	0,76	0,72
Support reaction force, N	1138,14	863,08	873,97	1205,47	1258,00	1262,51	1232,65	1232,39	1123,39

The study results are summarised in Table 1. According to the results of the study, it is recommended to hold the upper body at 0° when performing the side kick in counterattack, because the foot reaches the highest speed in this position (3,95 ± 0,04 m/s), with the shortest time taken to perform the kick (0,70 ± 0,01 s) as compared to the results obtained with other positions of the upper body.

Conclusions and discussion

In combat sports, athletes strive to strike the opponent with the highest speed and force (Gulledge & Dapena, 2008). In kickboxing, speed and force are necessary, because the combat pace is very fast, and athletes make kicks at great speed. Speed depends on the strength, but during the combat in such events as

point fighting, light contact, and kick light, it is important to control the force of kicks, because strong kicks are forbidden by the competition rules. The ability to control the force of the kicks during performance constitutes the difference between high-level athletes and amateurs.

Force is also necessary at the start of the kick, because the start of the kick is similar to the start of sprinting in track and field events. It is a complicated motor task characterised by great force that has an impact in multiple directions and by an ability to generate this force in a short period of time (Fortier, Basset, Mbourou, Favérial & Teasdale, 2005). As has already been mentioned, during the combat athletes perform kicks with great speed, but to develop this speed, the moment of the foot take-off is vital. The take-off stage for the foot influences the total performance speed of the kick. In the take-off stage, it is necessary to take the foot off the support with maximum speed, and strength is necessary to do this. Again, we conclude that speed is impossible without strength.

The initial position is an important factor in the athletic achievement in combat. In both attack and defence, athletes usually assume the position that is most comfortable for them (Estevan, Falco & Jandacka, 2011) or from which they can develop the greatest speed of the kick. Certainly, speed plays an important role in kickboxing, but, without sufficient preparation before the kick is performed, even high speed will not help to attack successfully. Before making a kick during combat, it is necessary to ensure the correct conditions are there: the position is comfortable and corresponds to the actions to be made. Accordingly, if an athlete wants to hit using hands in attack, the weight will be shifted more to the front foot. For a kick, the weight is to be shifted to the foot that is positioned to the back.

Estevan et al. analysed mechanic values, performing kicks in three positions of the upper body (0°, 45°, 90°). Mechanical measurements analysis was performed using two 3D force platforms and eight motion capture systems. The study found that the reaction and performance times are shorter in a hook kick when the upper body is at 0° and 45° than at 90°. Moreover, significant negative correlation was found for each upper body position between the ground reaction force maximum and the kick performance time. Furthermore, in each position of the upper body, the maximum force had positive correlation with the upper and lower leg speed. The scholars concluded that the body position influenced the athlete's kick performance techniques and recommended against athletes taking their upper body to the position of 90° from the vertical, as this prevents them from performing the hook kick in the best possible way (Estevan, Jandacka & Falco, 2013; Falco, Estevan & Vieten, 2011; Jandačka, Estevan, Janura & Falco, 2013).

In the current study, an analysis of the side kick was implemented likewise using force platforms and infrared motion capture cameras. Based on the results of the study, and in difference from the study of Estevan (Estevan, Falco &

Jandacka, 2011), the correlation between the speed of the side kick and the support reaction force in performing a side kick while standing, in moving forward and in counterattack in three positions of the upper body (0°, 45°, 90°) was not detected. In performing a side kick while standing and in moving forward, the lowest kick performance speed was registered for the upper body positions at 0° and 45°. The fastest kick was registered at the upper body positions at 0° and 45° similar to the study by Estevan et al. in performing a side kick with the front foot in counterattack, the shortest kick performance time and the fastest kick was registered with the upper body set at 0° to the vertical axis.

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