

Characterization of attack element execution speed in taekwondo ITF

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Summary

Taekwondo as a combat sport technique has a characteristic feature – very fast element execution, and it is one of the factors that determine how successful is a fight. One of the main tasks of the training process is to develop kick speed both in attack and counterattack, where an athlete should react adequately and execute a purposeful element as fast as possible to overtake his opponent.

In the training process a coach tries to perfect an athlete's technique and increase his speed ability. But the question arises how to test whether the applied method and means have increased the speed of the element execution by the trainee. In many cases the result will be stated subjectively observing the kick imitation or element execution in training

or competition fights. In the best case the result will be measured using a stopwatch, the fighter executing several kicks, taking the total execution time and dividing it by the number of kicks.

To evaluate objectively both the execution of the element technique (trajectory) and speed and acceleration in different kicking phases, it is necessary to apply more effective instrumental methods and carry out a detailed movement analysis. Nowadays technologies with high-speed video (100 Hz and higher) allow us to evaluate these parameters objectively. In many countries research is carried out in different combat sports, such as karate, taekwondo WTF (World Taekwondo Federation), etc. Unfortunately, in Latvia such research is not so widespread and is done only in some sports. So, it is valuable to introduce new technologies to research technique and speed ability in taekwondo ITF (International Taekwondo Federation), that will help to organize, perfect and control the study-training process better.

The aim of the research was stating of the attack element execution speed in taekwondo ITF. The data registration was done in LASE wrestling hall on taekwondo ITF special mat. Movement analysis was performed using two high speed Basler A602fc cameras (100 Hz) and SIMI Motion software. Light-reflecting markers were placed on three body landmarks: hip (Trochanter Major), knee (Condylus Lateralis) and ankle (Malleolus Lateralis). The research subject was a black belt (dan 1) taekwondo fighter (age 26 years; height 165 cm; weight 60.1 kg; experience in sport 15 years), first, second and third place winner at national and international tournaments. The present research is a pilot study. The experimental setup and necessary adjustments of methodology were tested using with participant, aiming at a further development of the research.

Keywords: taekwondo ITF, attack element execution speed, high-speed video recording, motion analysis.

Introduction

In order to achieve high results in competitions in combat sports today, the training process and control play a great role. One of the dominating tasks in taekwondo fighter preparation is the development of element execution speed. Applying different methods and means to develop speed the question arises whether the chosen exercises, dosage, relaxation time, etc. facilitate the increase of the expected result or not. Taekwondo kicks are executed very fast, so fast that it is almost impossible to see their execution with the unaided eye. The kick speed can reach 6-8 m/s, but the execution time is only 0.25-0.17 s (Villani R., 2005; Lee C. L., 2008; Hogmann M., Witte K., Emmermacher P., 2008). There is a problem how to state the element execution speed, as even the best experts cannot state it subjectively observing. Of course, there is a visible speed difference if we compare a beginner and a professional, but speaking about the result improvement by top fighters, a more detailed movement analysis is to be used. Objective data can be received only using a special video camera.

The analysis of combat special sources showed that movement analysis is done mostly in such sport as karate and taekwondo WTF, but unfortunately in taekwondo ITF there is almost no such research, especially in Latvia. We succeeded to contact an organization working with such device. The research methodology was worked out basing on personal knowledge and the literature by foreign authors.

The aim of the research was stating of the attack element execution time in taekwondo ITF.

The research tasks were as follows:

1. To state the attack element execution time in each of the phases.

2. To state the attack element execution speed in each of the phases.

3. To state the difference of speed and time between three kicks.

Research methods

The research subject was a black belt (dan 1) taekwondo fighter (age 26 years; height 165 cm; weight 60.1 kg; experience in sport 15 years), first, second and third place winner at national and international tournaments. Three kicks from standing position executed with the attack leg were analyzed in the research – frontal roundhouse kick with the front leg (Dollio chagi with the front leg), frontal roundhouse kick with the back leg (Dollio chagi with the back leg), side straight kick with the front leg (Yop chagi with the front leg). Each kick was executed by the same fighter three times. As a result the fastest executed trial was chosen from each kick motion analysis.

Using motion analysis software, time and speed are measured in each of the kicking phases. There are three kicking phases – preparatory, kicking and gathering phase. The preparatory phase starts with the flexion of the thigh of the kicking leg and taking the foot off the floor and finishes when the knee of the kicking leg is raised, but still the extension of the shin does not start. The next is the kicking phase with the extension of the shin in the direction of the kick and it continues till the full extension of the kicking leg. Then the gathering phase starts with the leg moving opposite the kicking direction by the same trajectory till the foot touches the floor.

These taekwondo kicks were chosen basing on the previous research (Saulite, 2008) where two World, two European and two Latvian Championship final fights were analyzed with the aim to find out the

most often used and the most successful elements in taekwondo. The frontal roundhouse and side straight kicks were the most used (27.2 % and 21.8 %).

Video recording took place in LASE wrestling hall on the special taekwondo ITF mat. Before the execution of the elements the taekwondo fighter warmed up with 10 minute jogging, general, special and stretching exercises. The fighter was acquainted with the aim of the research, tasks and the research process.

Motion analysis was performed using two high speed Basler A602fc cameras (100 Hz) and SIMI Motion software. Light-reflecting markers were placed on three body landmarks: hip (Trochanter Major), knee (Condylus Lateralis) and ankle (Malleolus Lateralis). Cameras were located on one side of the calibrated movement volume at angles, which provide for both cameras maximal visibility of all three markers during the whole studied range of the movement. After video recording of the movements points were digitized with SIMI Motion 3D software. In cases when any of the markers due to rotational movement of a body were out of cameras' field of view (up to 10 frames for one of the cameras), corresponding points were digitized manually.

Calibration of the movement volume was performed with SIMI laser calibration system in accordance with the developer's manual.

Research results

The results of kick speed were obtained from video recording. Figure 1 reflects the kick execution time result comparison between the 1st phase, 2nd phase and the total time. Comparing the kick results it can be seen that only the kick's Dollio chagi with the front leg the 1st phase execution is shorter than the second for 0.01 s. Other kicks have a longer 1st phase. The 1st phase of Yop chagi is longer for 0.03 s. Dollio chagi with the front leg has the shortest 1st phase, but for Yop chagi the 2nd phase is the shortest. However, the difference in phases execution time is significant only in case of Yop chagi.

In total according to kick execution time Dollio chagi with the front leg reaches the finishing point at the shortest time (0.23 ± 0.01 s), the second is Yop chagi and Dollio chagi with the back leg has the longest execution time (0.27 ± 0.01 s).

In the next three figures we can observe the intentions speed changes of the kick leg joints. The speed changes of the hip joint are marked with a red line, the speed of the knee joint – with a green one, but the speed of the ankle joint – with a blue one. The vertical red line marks

a finishing point of the 1st phase. Exactly at this moment the knee of the attack leg has reached the maximal flexion and the shin – the maximal extension.

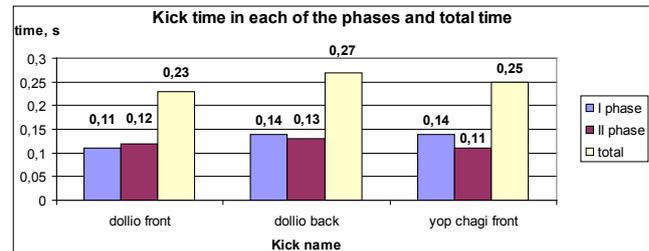


Fig. 1. Time of the kick

In figure 2 the kicking 1st phase (preparatory phase) finishes in 0.11 ± 0.01 second after taking the kicking leg off the floor.

Visually observing it is seen that the greatest speed of the hip joint is in the very beginning of the kick, then it gradually decreases till stops fully. Knee speed increases till the end of the 1st phase, then with shin extension the speed decreases quickly, then only after the 2nd phase it stops decreasing. It was very interesting to observe the dynamics of the ankle joint speed. At 0.08 ± 0.01 s the kick speed reached the highest result in the 1st phase (about 6 m/s) then it decreased. In the beginning of the 2nd phase it started to increase rapidly and in 0.18 ± 0.01 second reached the highest kick speed (around 7.8 m/s). Only this line has a wavelike speed dynamics with two speed maximums.

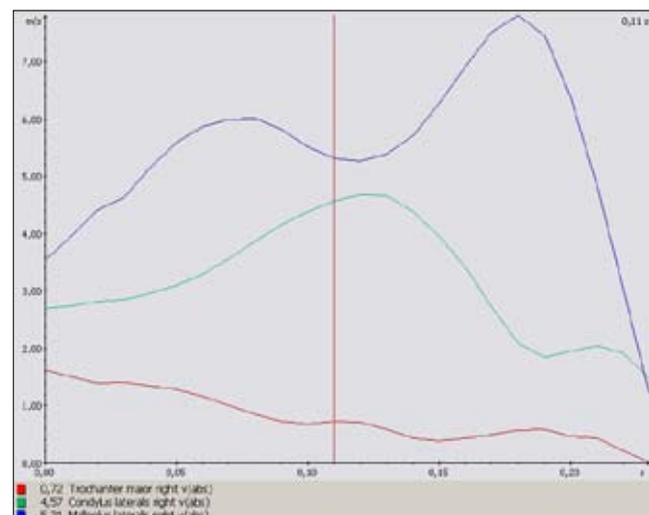


Fig. 2. Speed of the frontal roundhouse kick with the front leg (Dollio chagi with the front leg)

In Figure 3 we can observe the joint speed dynamics of the frontal roundhouse kick with the back leg. The 1st phase of the kick execution finishes in 0.14 ± 0.01 second. It is seen in the figure that the knee joint has a slightly higher speed in the beginning of the 1st phase than the ankle joint, as in the beginning

of the kick the knee starts a movement forward, but the ankle – upward. Almost parallel speed increase of the knee and ankle joints is characteristic till the end of the 1st phase, then the ankle joint speed continues to increase up to almost 11 m/s (in the 22nd second), but the knee speed starts to decrease. Hip joint moves with the speed ~3 m/s, and close to the end of the 1st phase it starts to decrease.

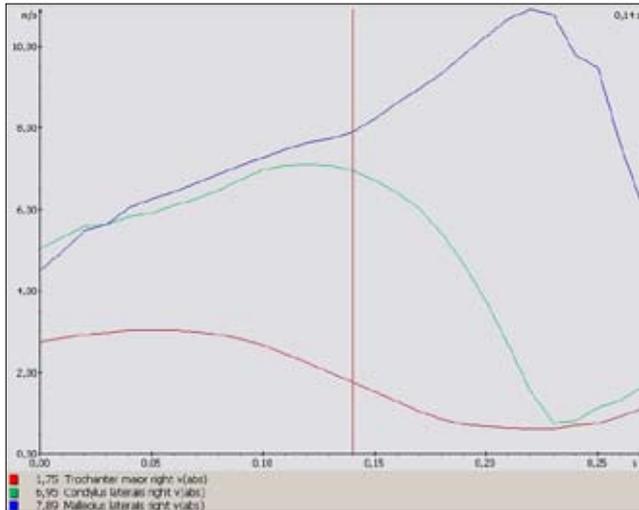


Fig. 3. Speed of the frontal roundhouse kick with the back leg (Dollio chagi with the back leg)

In Figure 4 we can observe the joint speed dynamics of the side straight kick with the front leg. In the beginning of this kick we can see an almost simultaneous speed increase of the knee and ankle, and before the 2nd phase the knee speed starts to decrease, but the ankle for 0.03 ± 0.01 s stops at speed 6 m/s, then it starts to increase up to 7.7 m/s (in the 20 ± 0.01 second). The speed of the hip joint gradually increases up to almost 1.6 m/s then it decreases to the initial speed.

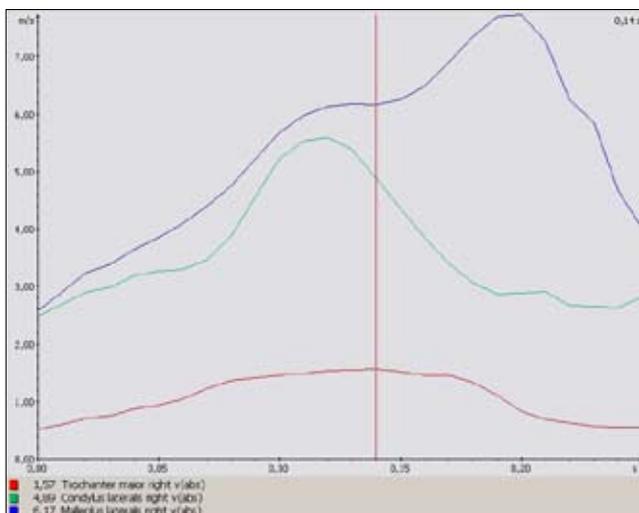


Fig. 4. Speed of the side straight kick with front leg (Yop chagi with front leg)

Figure 5 reflects the comparison of the maximal speed of the joints of the kicking leg between all researched kicks.

Dollio chagi with the back leg has the highest hip joint maximal speed (around 3.0 m/s), the next is Dollio chagi with the front leg (1.6 m/s) and Yop chagi (also around 1.6 m/s). however, if observing closer the maximal hip joint speed during Yop chagi appears even slightly slower, than during Dollio shagi.

Dollio chagi with the back leg has also the highest knee joint speed (almost 8.0 m/s), the next is the speed of Yop chagi kick (~5.6 m/s), but Dollio chagi with the forward leg has the lowest speed.

Analyzing the joint speed of three kicks it can be seen that in total Dollio chagi with the back leg has reached the greatest speed.

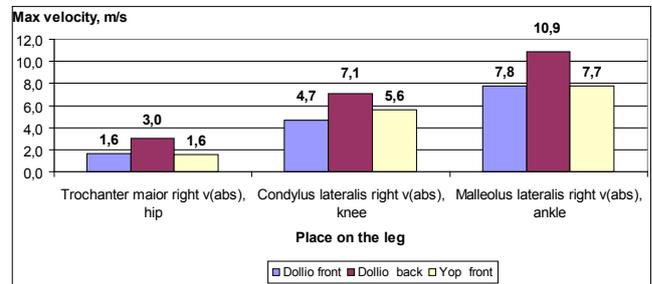


Fig. 5. Kick max speed of joint movement

Discussion

The determination of speed parameters by high-speed video recording in combat sports starts to become widespread all over the world. We should also start to use this objective methodology when estimating technique and physical abilities.

In the research three taekwondo ITF kicks were executed by one fighter. As the present research is a pilot study and one of its objectives was optimization of motion analysis performance process, participation of only one subject is considered sufficient. The performed pilot study revealed necessary adjustments that have to be made to the experimental set up in order to obtain full data range of joint movements.

Speaking about the kick execution time, Dollio chagi with the front leg reached the finish point in the shortest period (0.23 ± 0.01 s), the next was Yop chagi with the front leg (0.25 ± 0.01 s), and the last - Dollio chagi with the back leg (0.27 ± 0.01 s). Analyzing the phase times it can be seen that in Yop chagi with the front leg the 1st phase is longer than the 2nd phase for 0.03 s. It can be explained by the fact that two joints simultaneously – the hip and knee joint – participate in leg extension. The phase length of the other two

kicks differs only in 0.01 s, which is within the limits of error probability. Analyzing the speed dynamics of all kicks the one of Dollio chagi with the front leg should be emphasized. From all three researched kicks only this kick's speed dynamics is wavelike with two speed maximums. The other two kicks have almost the same speed diagrams, characterized by the knee and ankle joint simultaneous speed increase in the beginning of the kick, then in the 2nd phase there is a drop in knee speed, but the ankle speed continues to increase.

Speaking about the kick maximal speed results in all joints, Dollio chagi with the back leg has the greatest result (hip ~ 3.0 m/s; knee ~7.1 m/s; ankle ~ 10.9 m/s). The two other kicks are almost similar according to the parameters of maximal speed. Such contradictory results can be explained by the fact that the kicks with the front leg should move a relatively small distance from the beginning to the finish point, but the back leg should cover much bigger distance, equal with the fighter's stance height. Therefore the kick with the back leg approaches the finish point later, however the fighter tries to compensate the distance with the movement speed. Having a greater kicking distance the fighter manages to develop a greater speed of the leg.

We should also keep in mind, that as only one subject participated in this pilot study the obtained data might in a great extent describe the individual characteristics of the subject. This latter assumption will be examined in further researches.

Conclusions

Analyzing the research results it can be concluded that the fastest kick according to time criteria is Dollio chagi with the front leg (0.23±0.01 s), then after 0.02 seconds comes Yop chagi with the front leg (0.25±0.01 s), and after two more seconds - Dollio chagi with the back leg.

Speaking about the kick maximal speed results in all joints Dollio chagi with the back leg has the

greatest result (hip ~ 3.0 m/s; knee ~7.1 m/s; ankle ~ 10.9 m/s).

The kick speed in the preparatory and finishing phase of the kick is analyzed in the article. It can be concluded that the duration of both phases is almost the same, except Yop chagi with the front leg, where the 1st phase of the kick is about in 0.03 s longer than the 2nd phase.

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TEKVONDO ITF PUOLIMO VEIKSMO ATLIKIMO GREIČIO CHARAKTERISTIKA

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SANTRAUKA

Tekvondo, kaip dvikovos sporto šakos, technika turi charakteringą bruožą – labai greitą veiksmo atlikimą, ir tai yra vienas iš veiksnių, lemiančių kovos sėkmingumą. Viena iš pagrindinių treniruotės vyksmo užduočių – išstbulinti spyrių koja tiek puolant, tiek ginantis, kai sportininkas turi adekvačiai reaguoti ir atlikti tikslingą veiksmą kuo greičiau, kad nugalėtų priešininką.

Treniruotės vyksme treneris stengiasi išstbulinti sportininko techniką ir padidinti jo vikrumą. Tačiau išskyla klausimas, kaip patikrinti, ar taikytas metodas ir priemonės padidino treniruojamo veiksmo atlikimo greitį. Daugeliu atvejų rezultatas įvertinamas subjektyviai stebint spyrio koja imitavimą arba veiksmo atlikimą treniruojantis ar varžybų kovos metu. Geriausiu atveju naudojamas chronometras – kovotojas atlieka keletą spyrių koja ir tada visas atlikimo laikas padalijamas iš spyrių koja skaičiaus.

Siekiant objektyviai įvertinti tiek veiksmo technikos atlikimą (trajektorija), tiek greitį ir pagreitį skirtingose spyrių koja fazėse, reikia taikyti veiksmingesnius instrumentinius metodus ir atlikti detalią judesių analizę. Dabar didelio greičio (100 Hz ir daugiau) vaizdo technologijos leidžia mums objektyviai įvertinti šiuos parametrus. Daugelyje šalių atliekami įvairių dvikovos sporto šakų, tokių kaip karatė, tekvondo WTF (*World Taekwondo Federation* – Pasaulinė tekvondo federacija) ir t. t., tyrimai. Deja, Latvijoje tokie tyrimai

nėra labai paplitę ir atliekami tik kai kurių sporto šakų. Taigi, būtų labai naudinga įdiegti naujas technologijas į tekvondo ITF (*International Taekwondo Federation* – Tarptautinė tekvondo federacija) sporto šakos tyrimų metodiką ir judesių greičio nustatymą, tai padėtų geriau organizuoti, tobulinti ir kontroliuoti mokymo bei treniravimo procesą.

Tyrimo tikslas – nustatyti tekvondo ITF kovotojo puolimo veiksmo atlikimo greitį. Duomenys registruoti Latvijos kūno kultūros akademijos imtynių salėje ant specialaus tekvondo ITF kilimėlio. Judesių analizė atlikta naudojant dvi didelio greičio *Basler A602fc* kameras (100 Hz) ir *SIMI Motion* programinę įrangą. Šviesą atspindintys ženklai buvo užlipdyti trijose kūno vietose: ant klubo (*Trochanter Major*), ant kelio (*Condylus Lateralis*) ir ant kulkšnies (*Malleolus Lateralis*). Tyrimo objektas buvo tekvondo kovotojas, turintis juodą diržą (pirmas danas), 26 m. amžiaus, 165 cm ūgio, 60,1 kg svorio, turintis 15 m. sportinę patirtį, 1–3 vietų laimėtojas šalies ir tarptautinėse varžybose. Tyrimas buvo bandomasis. Eksperimentinė įranga ir reikalingos metodologinės pataisos buvo išbandytos su tyrimo dalyviu siekiant tolesnio tyrimo plėtojimo.

Raktažodžiai: tekvondo ITF, puolimo veiksmo atlikimo greitis, didelio greičio vaizdo įrašas, judesių analizė.

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