Structure of movement of a turning technique used in the event of special techniques in Taekwon-do ITF

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

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Abstract

Background: One of the kicks performed in the event of special techniques in taekwon-do ITF is the flying reverse turning kick (according to the taekwon-do terminology: *twimyo bandae dollyo chagi*). To make a competitor kick in the best way, it is necessary to know all the elements responsible for a good kick, in order to get the best sports result. The flying turning kick is a difficult movement that requires a lot of physical fitness. When you start to learn a technique, you should learn the details of the structure of the movement, what the posture of the body is and what factors influence the movement.

Material/Methods: A 17-year-old competitor weighing 75 kg and measuring 179 cm with the International Championship Class was analyzed. He performed a flight reverse turning kick. With the use of the BTS Smart system, data about the relocation and speed of characteristic point of the competitor's body was obtained. Parameters which describe the spatial and time structure of the movement were analyzed.

Results: For the aims of the above analysis, the movement was divided into four phases: starting posture, take-off, flight and turning, landing. Biomechanical parameters influence the efficiency of the kick: maximum height OSC 1453.70 mm; maximum height of the foot 2103.50 mm; maximum speed of the foot 9,6 m/s; the speed at takeoff of COG 2.43 m/s; maximum force of reaction of the basis 1125.15 N

Conclusions: The conclusion from the research is that the height of the jump depends on four basic elements: the height of the centre of gravity at the moment of jumping, the height of jumping of the COG, the height of flying of the COG and the height of rising the kicking leg. The height of the COG depends on somatic features and the posture of the body. The height of the jump is a function of motoric features. The bigger the Y component of the speed of jumping and change of vertical speed (which is influenced by the force of jumping and the rotational movement of the legs and torso), the higher the height of flying of COG. The height of rising the kicking leg depends on the angle speed and the position of the body when the kick is performed.

Key words: taekwon-do • special techniques • *twimyo bandae dollyo chagi* • evaluation of technique's jump

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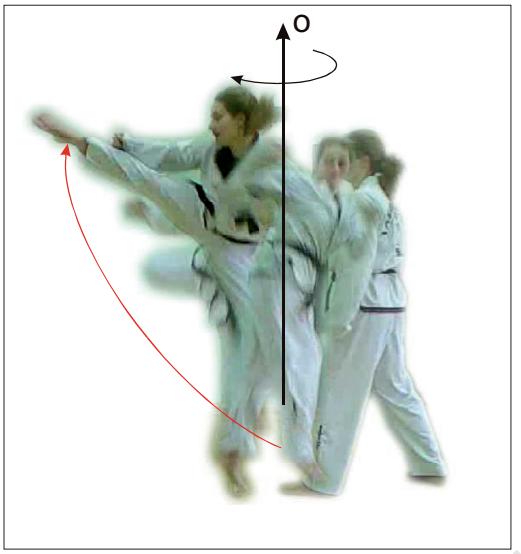
Background

Nowadays martial arts are an important element of physical activity of societies. They are recommended because a competent use of martial arts and sport in the education of young people influences in a positive way the obedience of ethical norms in the society [1–4]. Most well-known martial arts introduced a system of sports competition. Some of them are included in the program of the Olympics (judo, **taekwon-do** WTF). The aims of practicing martial arts has changed and it is the reason why the training methods have changed as well; the training process and programs must be adapted to the needs of sports rivalry [5–8]. **Special techniques** are a characteristic sports event in ITF [9,10].

Taekwon-do: a Korean martial art based mainly on punches and kicks.

Special techniques: a sports event in taekwon-do ITF.



Twimyo bandae dollyo chagi: turning technique used in the event of special techniques in taekwon-do ITF.

Figure 1. The movement during a flight reverse turning kick (in taekwon-do terminology: twimyo bandae dollyo chagi).

the norms of sports events were being created, it was thought that this kind of event would help in further development of taekwon-do students because this technique requires big physical fitness and special skills; it will also make sports competition more attractive. At the beginning the aim to break were boards attached to holders, then a special construction called "machine for special techniques" was built. Now a high level of competition makes coaches and competitors search for better and better training solutions.

One of the kicks performed in the event of special techniques in taekwon-do ITF is the flying reverse turning kick (according to the taekwon-do terminology: ***twimyo bandae dollyo chagi***) presented in Figure 1. To make a competitor kick in the best way, it is necessary to know all the elements responsible for a good kick, in order to get the best sports result. The flying turning kick is a difficult movement that requires a lot of physical fitness. When you start to learn a technique, you should

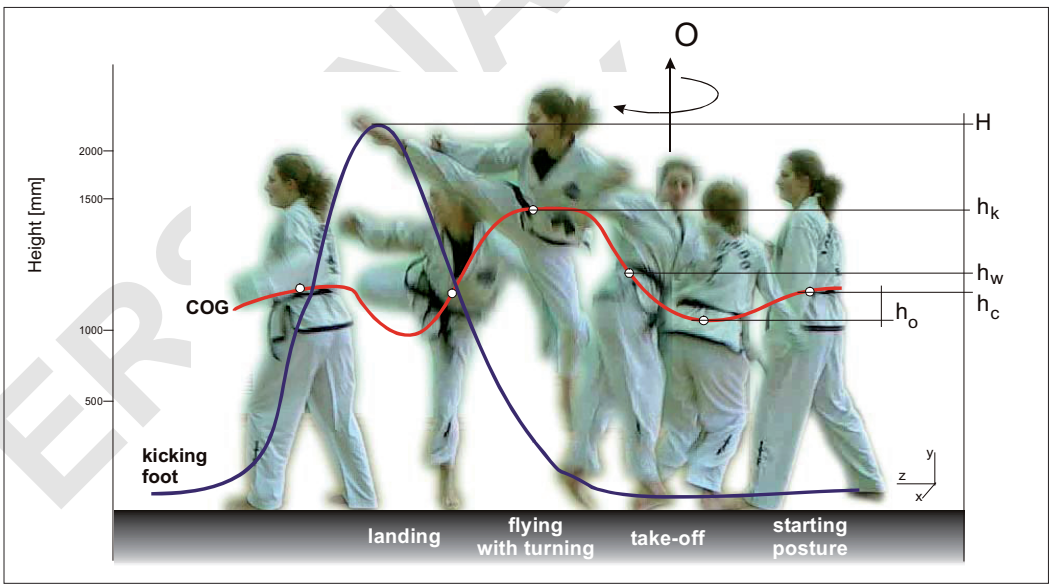


Figure 2. Phases of the kick twimyo bandae dollyo. hc – the starting posture of the Centre of Gravity (COG): ho – the height of the COG at the moment of jumping, hw – the height of jumping of the COG, hk – the height of flying of the COG, H – the height of rising the kicking leg.

It consists of performing a different kind of jumping kick and breaking a board placed at the height of 2 or 3 meters (sometimes higher). This event follows the tradition of using these kicks in practice. They were created to throw a rider off the horse (who is out of reach of kicks and punches from the ground), knocking a weapon off the hands of a shooter who is standing on a high shooting platform or help a friend fighting on an elevated place.

During preparations to fights (trainings) students competed with each other to kick higher and higher. When learn the details of the structure of the movement, what the posture of the body is and what factors influence the movement.

A competitor starts the kick from the posture called L-stance (according to the taekwon-do terminology: *niunja sogi palmok daebi makgi*). In case of *twimyo bandae dollyo chagi* competitors generally do not run, sometimes they only make a step preceding the jump. It is the result of the specification and complexity of the movement and of the fact that it is easier to direct the movement in space.

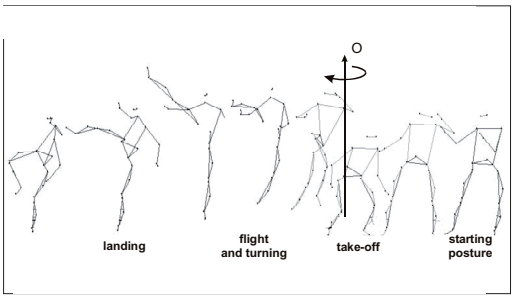


Figure 3. Phases of the movement: twimyo bandae dollyo chagi shown with the help of the BTS Smart system.

The aim of this work it so search for a biomechanical optimalization of *twimyo bandae dollyo chagi*, a more effective method of performing this kick and winning the event of special events in taekwon-do ITF. Taking into consideration the criteria of biomechanical analyses of sports technique used so far [11] and particularly the ones used to measure taekwon-do techniques [12,13], four phases of the movement were recognized in this casuistic research: starting posture, take-off, flight and turning, landing.

The following research questions were asked:

1. Can the method of analysis of phases of the complicated taekwon-do technique used in the research be useful to optimalize the training?
2. What biomechanical parameters influence the efficiency of the kick?

Material and Methods

A 17-year old competitor with the weight of 75 kg and the height or 179 cm with International Sports Class was analysed. During the research, the competitor performed a flying turning kick. The structure of the movement is shown in the Figures 1–3.

A system of complex analysis of movement called Smart-D made by the Italian company BTS Spa was used for the tests. It consists of six cameras reflecting emited infrared light, which read the placement of markers on the competitor's body in the real time. Thanks to this fact it was possible to register the movement of the body and evaluate kinestetic parameters. Calibration allowed registration with the accuracy of 0.3–0.45 mm. The record was made with the frequency of 120 Hz.

Obtained data concerning the dislocation and speed of characteristic points on the competitor's body were analysed by defining indicators which describe the structure of space and time of the movement.

A „machine for special techniques" was used for the measurement, which is a device used during sports competition. The aim of the competitor was to perform the kick in their typical way in this event.

In the analysis of particular phases of the movement the following factors were taken into consideration.

Results

Starting posture: A competitor is standing in the posture called L-stance. (according to the Taekwon-do terminology: *niunja sogi palmok daebi makgi*) with the right leg forward. The heel of the left leg makes more or less one line with the toes of the right foot. Both knees are slightly bent. 70% of the body weight is on the rear leg, 30% on the front leg. Now information about the place of beginning of the kick and the posture of the body is provided.

Take-off: The takeoff was made with two legs and it started at the moment when the body was lifted from the starting posture. Then the centre of gravity got lower (h_o) and the arms and torso turned in the opposite direction from the direction of the kick. At this moment the competitor's body tensed, the arms were lifted up and to the sides. When the soles of the feet touched the ground, the knees tensed and the athlete made his body rise from the ground in an energetic movement strengthening his hips, knees and ankles (h_w). In the result the force pushed the competitor up and his body rotated around the sagittal axis. The height of the jump mainly depended on the movement of the legs and the rotation depended on the movement of the arms.

Flight and turning: Most of happens with the competitor's body is a result of the take-off. The competitor's parts of body cooperated; he rotated around the sagittal axis and straightened the kicking leg while „hanging" in the air (h_k). The heel of the kicking leg went in a semi-circle making the angle of about 75 degrees. Then it bended when the competitor was going to land.

Landing: It is an important part of the jump because it must be done correctly if the techniques is going to be approved by referees. The leg which is not kicking is the supporting part. The competitor balanced his body in such a way that the he touched the floor only with his feet.

The next phases of the kick *twimyo bandae dollyo chagi* are visible in the Figures 1–3. In case of this techniques, normally competitors do not take a run-up. Therefore it can be said that the dynamics of the kick depends on the jump and rotation movement of the arms. At the moment of lowering the body, the jumping phase begins and lasts for about 0.3 sec. Then gradually the

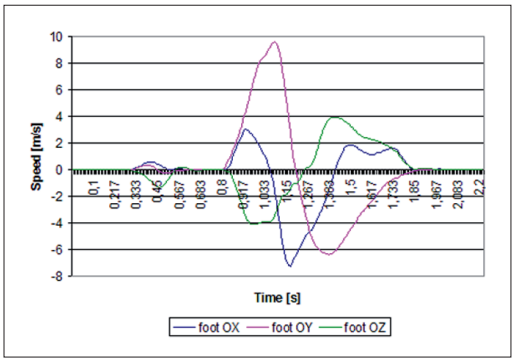


Figure 4. Change of linear speed of the kicking foot in space.

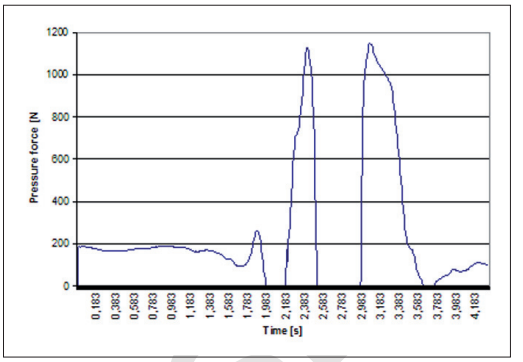


Figure 5. Reaction force of the basis while performing twimyo bandae dollyo chagi.

Table 1. Maximum linear speed of the kicking foot in space.

Max speed OX	Max speed OY	Max speed OZ
3.0143	9.5937	3.9186

Table 2. Biomechanical parameters influence the efficiency of the kick.

The flying reverse turning kick – Timyo bandae dollyo chagi	
Maximum height COG (h_k)	1453.70 mm
Maximum height of the foot's centre of mass (H)	2103.50 mm
Maximum speed of the foot's centre of mass (OY)	9.60 m/s
The speed at takeoff of the centre of gravity (OY)	2.43 m/s
Maximum force of reaction of the basis	1125.15 N

centre of gravity raises and the arms continue the rotation movement.

The goal of the swing of the arms is:

- to transfer the moment of force and make the body rotate,
- to increase the force of the jump generated by the competitor by rising the centre of gravity during the take-off.

When the jumping finishes, the phase of flying with rotation begins, which lasts for about 0.4 sec. Two stages can be observed in it: „stringing the bow" and „releasing the bowstring". In the first stage the torso turns and gives energy to the leg. In the second stage the leg straightens in the hip until it reaches the target. The leg gains speed when going towards the target. Obtained results show that the maximum linear speed which raises the foot gets to 9.6 m/s. The flying phase is finished with landing on one leg. During this measuring, the centre of gravity rose to 1453.7 mm and the centre of mass of the kicking foot to 2103.5 mm. The time of the whole movement was about 1.2 sec.

Figure 4 shows us the course of linear speeds of the centre of gravity of the foot which is used to kick towards three axis in the space X,Y,Z. From the course of curves and from Table 1 it is visible that the biggest speed is reached by the foot towards OY. It is probably the result of the competitor's goal – his aim was not to obtain the biggest force but the maximum height of the kick. Figure 5 presents the course of the reaction of the ground during performing twimyo bandae dollyo chagi. Till 2.183 sec there are preparation movements. From 2.183 sec till about 2.58 sec the moment of jumping from the ground occurs. The force of reaction of the ground reaches the value of 1125.15N within the time of about 0.2 sec. Beween 2.58 and 2.98 sec the phase of flying with turning takes place, then the landing. Biomechanical parameters influencing the effectiveness of the kick are shown in Table 2.

Discussion

The conclusion from the research is that the height of the jump depends on four basic elements: the height of the Centre of Gravity (COG) at the moment of jumping (h_o), the height of jumping of the COG (h_w), the height of flying of the COG (h_k) and the height of rising the kicking leg (H). The height of the COG depends on somatic features and the position of the body. The height of the jump is a function of motoric features. The bigger the Y component of the speed of jumping and change of

vertical speed (which is influenced by the force of jumping and the rotational movement of the legs and torso), the higher the height of flying of COG. The height of rising the kicking leg depends on the angle speed and the position of the body when the kick is performed.

„Special techniques", or jumping kicks at maximum height have a strictly utilitarian genesis. In anti-terrorist units there are people with uncommon skills whose goal is to react to different kinds of danger. More and more often we face untypical forms of attack which require untypical forms of reaction. That is why we want our „defeders" to be very fit and take extreme actions. We can imagine a situation when a terrorist is standing on an elevated point and trying to fire. Special techniques of taekwon-do can be further included in the evaluation system of psychomotor competences [14]. Life of a big number of people may depend on the fact if he will be neutralized in a split of a second. The system of sports competition is a factor that allows people to reach mastery and maximalize their physical fitness. It prepares a person to reach extreme abilities.

A lot of researchers are looking for ways of biomechanical optimalization of the movement [15,16]. It does not matter if they want to describe walking or running, everybody is looking for a method to obtain bigger values of parameters of the movement with as little work as possible. My work describes only a fragment of the problem. It is certain that a bigger number of people should be examined and it is worth thinking how the movement of the arms influences the height and the strenght of the kick. I think that arms will work in a different way in space if we want to obtain the biggest height and in a different way if our aim is to get maximum power of the kick. It may also be interesting to know if making a step before the kick has any influence on the kick's parameters.

The results and reflections presented here may be a comparison for other values and they might be the basis for other examinations.

Conclusions

1. The method of analysis of *twimyo bandae dollyo chagi* used in the research can also be used to measure the mechanics of movement of other special techniques of taekwon-do.
2. Comparing individual characteristics of mechanics of movement of high class taekwon-do competitors makes it possible to verify if these four elements really influence the height of the jump: the height of the COG at the moment of jumping, the height of the COG during the jump, the height of flying of the COG and the level reached by the foot.
3. The results of the research proved two issues:
   - the height of a jump will be higher if the rising component of the speed of jumping is higher,
   - the rising component of the speed of the jump is influenced by the power of jump coming from the legs and the rotation movement of the arms.

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