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The physical basis of the twimyo nomo yop chagi test in taekwon-do ITF

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Authors' contributions:
A Study design
B Data collection
C Statistical analysis
D Data interpretation
E Literature search
F Manuscript preparation
G Funds collection

Summary

Study aim: The aim of this paper is the finding of the optimum conditions for the preforming of the *twimyo nomo yop chagi*. Allowing the competitor to achieve the best possible results.

Material/methods: This paper contains the theoretical description of the test, from the physical point of view.

Results: During the special technique test, the height that the competitor successfully completes, is a sum of 3 distances: the distance between the point of takeoff, and the COG, the horizontal distance that the COG overcomes during the flight phase, the distance between the COG and the landing spot. This is shown by the following formula: $D = m_o + d + m_l$. The combination of the horizontal speed generated during the run up and the vertical speed obtained during the takeoff determines the angle of takeoff: $\alpha = \arctan \frac{v_y}{v_x}$.

Conclusions: After the analysis of this technique we are able to determine the factors that influence the distance of the jump. These factors are: the force of the takeoff, takeoff velocity the angle of takeoff. The takeoff velocity is the most important factor, it depends on the velocity during the run up and the change of that velocity during the takeoff. Physics has shown that the best takeoff angle in order to achieve the best distance is 45 degrees. In order to achieve this angle the time of takeoff must be very short and the velocity very high. The perfect combination would be to achieve the maximum velocity and a minimum loss of this velocity during the preparation for the takeoff, and the takeoff itself is to take place in the shortest possible period of time.

Key words: **Taekwon-do • special techniques • jump evaluationls**

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Background

The knowledge about the maximum efficiency of a technique is not only meant for sport purposes. The law of one chance [5] is correctly associated with the "constant alert state". Based on the analysis of the David vs. Goliath [7] fight one can say that David had only one chance for winning and he used it. A similar situation can take place in real life when a powerfully and armed opponent stands across the victim. Perhaps one jump over an obstacle that will punch out the weapon from the aggressors hand or one hit to a vital spot will save the victim. Of course in order to achieve such precision and power one must practice.

Special techniques are a competition that makes ITF Taekwondo different from other martial arts. Although in other martial arts flying kicks are represented, only in Taekwon-do competitors have mastered them in a way that has allowed the introduction of a separate competition that is based on flying kicks. The competition of special techniques consists of 5 tests [1, 2]. Two of the techniques are similar to the high jump events (timyo nopi ap chagi, timyo dollyo chagi), two of them are based on spinning kicks (timyo bandae dollyo chagi, twimyo tora yop chagi) the remaining test/technique is similar to the long jump (nomo yop chagi). The competitor is forced to overcome an obstacle (tape hanging between two pols starts and ends the obstacle). If at any moment the competitor causes the brake of the tape the test has failed. The height at which the tape is suspended depends on the age of the competitors (tab. 1), the length of the obstacle is also set by *The Rules And Regulations of the PZTKD* [6].

Material & methods

This theses is the theoretical description, based on the physics, of the *Twimyo Nomo Yop Chagi,* and its purpose is to find the optimal way of conducting the above mentioned test that will enable the competitors to achieve the best possible results.

Theses [8] has shown that the height that the competitor achieves in other techniques can be divided into 4 parts. This jump can be shown as s sum of 3 different distances:
– the distance between the point of takeoff, and the COG (m_o)
– the horizontal distance that the COG overcomes during the flight phase (d),

consisting of the following distances:
a. the horizontal distance of the COG before the obstacle (o)
b. the horizontal distance of the obstacle (d_p)
c. the horizontal distance of the COG behind the obstacle (1),
– the distance between the COG and the landing spot (m_l)

Results and Discussion

The distance at which an athlete breaks the target board can be described by the following equation:

$$D = m_o + d + m_l \quad \text{or} \quad D = m_o + o + d_p + l + m_l$$

The jumper running with the velocity v_0 takes off and his COG reaches the altitude of h_1, and during the landing decreases that altitude by Δh. Disregarding the air resistance.

The distance overcame by the COG is [3]:

$d = v_x(t_{wz} + t_{op})$, t_{wz} – time of gaining altitude; t_o – time of the decreasing of the altitude

$$t_{wz} = \sqrt{\frac{2h_1}{g}} \quad t_{op} = \sqrt{\frac{2h_1 + \Delta h}{g}}$$

The velocity v_x can be calculated using the following formula:

$$v_0^2 = v_x^2 + v_y^2 \Rightarrow v_x = \sqrt{v_0^2 + v_y^2} \quad \text{where} \quad v_y = \sqrt{2gh_1}$$

Table 1. The height of the suspension and the length of the obstacle for the particular age groups for the *Twimyo Nomo Yop Chagi* set by The PZTKD.

Age groupe	Gender	Length [cm]			Height [cm]
		min.	average	max.	
Younger Junior	Female	130	160	190	40
	Male	200	230	260	50
Junior	Female	230	260	290	50
	Male	150	180	210	60
Senior	Female	170	200	230	60
	Male	260	290	320	70

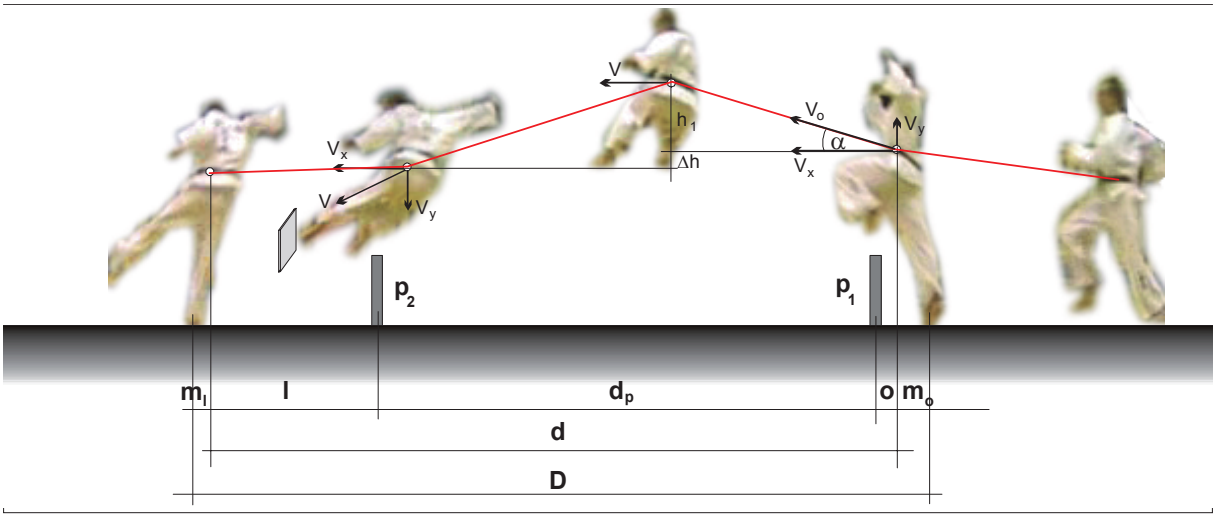

Figure 1. Phases of the twimyo nomo yop chagi test.

therefore:

$$d = \sqrt{v_0^2 - 2gh_1} \cdot \left[\sqrt{\frac{2h_1}{g}} + \sqrt{\frac{2h_1 + \Delta h}{g}} \right]$$

In the situation that the competition takes place indoors the influence of air resistance is so small that it can be disregarded. But in case of outdoors competition air resistance can have a big influence on the distance of the jump. In the case of the long lump the wind speed over 2 m/s stops the competition. The air resistance changes the velocity of the run up as well as the velocity of the flight, and in this way can change the distance of the jump.

The *Twimyo Nomo Yop Chagi* can be divided into 4 phases: the run up, takeoff flight phase and the landing. The takeoff begins at the moment of touchdown of the takeoff foot to the ground at the end of the last stride of the run up and lasts till the moment when this foot takes off, moving the COG. At that moment the body of the competitor is accelerating upwards. The length and height of the jump depends on this phase of the test. During the flight phase the competitor begins the delaying phase, the delaying factors are gravity and air resistance. The target for this test is a board that can be placed even 3 meters from the takeoff point. Therefore the length not the height of the jump is most important for the competitor. The factors that influence the length of the jump are the same as in the case of any projectile: speed, the angle of takeoff, the height of the takeoff and the air resistance during the flight. The combination of the horizontal speed generated during the run up and the vertical speed obtained during the takeoff determines the angle of takeoff [4]:

$$\alpha = \arctan \frac{v_y}{v_x}$$

α – angle of takeoff; v_y – COG's vertical velocity; v_x – COG's horizontal velocity

The horizontal velocity of the competitor is influenced by the speed generated by the competitor during the run up. The faster the run up the less time the foot of the jumper touches the ground during the takeoff and that decreases the vertical speed of the competitor at the instant of the takeoff.

Conclusions

Drawing 1 shows a competitor during the twimyo nomo yop chagi. In order to achieve the optimum distance the competitor must generate a high velocity during the run up, must have a very strong take off, in such a way that will not decrease the velocity obtained during the run up. In theory it seems to be very simple, put in real life it is a very complex process. Human beings are very ineffective jumpers. We are not able to use even the half of the kinetic energy and change it into potential energy without any machines.

After the analysis of this technique we are able to determine the factors that influence the distance of the jump. These factors are: the force of the takeoff, takeoff velocity the angle of takeoff. The takeoff velocity is the most important factor, it depends on the velocity during the run up and the change of that velocity during the takeoff. Physics has shown that the best takeoff angle in order to achieve the best distance is 45 degrees. In order to achieve this angle the time of takeoff must be very short and the velocity very high. The perfect combination would be to achieve the maximum velocity and a minimum loss of this velocity during the preparation for the takeoff, and the takeoff itself is to take place in the shortest possible period of time.

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