

Biomechanics' Determinants of the Trunk Front Semi-Circular Kick (Dollyo Chagi) in Tae-Kwon-Do

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Abstract: Biomechanics' determinants of the trunk front semi-circular kick (Dollyo Chagi) in Tae-Kwon-do Represents the logical analysis of motor vehicle by which the subject of the study dealing with the phenomenon after the fragmentation of the primary elements to achieve a deeper understanding of the phenomenon as a whole. Taekwondo is a Martial Arts Olympics, can the player according to new 2009 amendments to the law in favor of ending the game in case the performance of three to four kicks during the match in just any tour as a special circular front kick (Dollyo Chagi), which ranked first in the skills the most commonly used in games, used to kick in each of the trunk and face of the player. The researchers noted the importance of that skill and importance of studying various aspects of technical, mechanical, prompting researchers to try to study the properties of the curve front kick circular (Dollyo Chagi) in the sport of Taekwondo.

- The equity of the total time of performing the skills was in favor of the right and left where it reached (0.76 s.)
- The amounts of the longest horizontal displacement of the kicking metatarsus was by 1.505m for the right foot kick and 1.477m to the left foot kick, with a difference of 0.028m represents a percentage of 1.86% which is . The amounts of the longest vertical displacement was by 1.597 m while the left foot kick achieved a vertical displacement of 1.531 m, with a difference of 0.066 m which is a very small difference that indicates the extent of accuracy when performing the skill with the two feet and represents a difference ratio of 4.13%.
- The highest rates of total speed of the difference between the obtained speed with a percentage of 4.05%.
- The largest rate of the kicking foot ankle's angular change ranged between (171.743°) to (160.038°) with a difference of (11.7°) with a ratio of (6.8%) which is a high percentage refers to the need of studying the causes of the differences between the two kicks of both feet.
- The largest rate of the kicking foot knee joint's angular change during the performance ranged between (179.73°: 178.201°) with a difference of (1.52°) with a ratio of 0.84%, which is an excellent rate for achieving the further and higher horizontal and vertical distance of the kicking foot.
- The largest rate of the hip joint's angular change ranged between (147.2°) to the right foot kick and (151.08°) to the left foot kick at (0.56 s.) with a difference of (3.12°) with a percentage of 2.06%
- The kicking foot pushing amounts ranged between 8.825n/s. for right foot pushing and 10.662 n/s. for left foot pushing with a different of 1.83 n/m. represents a percentage of 17.22%.

Key words: Dollyo Chagi • Tae-Kwon-Do

INTRODUCTION

The methodological formulation of the motor performance procedures is considered one of the leading topics of interest to those working in the

field of scientific diagnosis of the sports movements and appropriate scientific solutions to performance problems in the championships sector as an aspired aim by all theories and fundamentals of the associated sciences [1].

Tae-Kwan do is an Olympic self-defense sport, which has increased interest both scientifically and sports after inclusion in the official Olympic program starting from Sydney 2000 Olympic Games, after being within the informal shows Olympic tournaments, which entered starting from Seoul 1988 [2]. Although Tae-Kwon-do is similar to some other martial arts sports like Karate and Kung- Fu, it discriminates by the unique using with a large percentage of the legs skills (kicks), which represent more than 90% compared to hand skills in Tae-Kwon-do matches. Moreover, the attention to using kicks in matches increased recently, especially the trunk front semi-circular kick (Dollyo Chagi), which is used to kick the opponent's trunk and face, after the last amendments to the rules of the game in 2009 [3].

The trunk front semi-circular kick (Dollyo Chagi) is also considered the most important kicks in the sport of Tae-Kwon-do. It ranks first in the skills most commonly used in the matches for it characterizes with the diversity of performance methods, speed of execution and the possibility of performing it by the front or back foot. The importance of the kick made the researchers eager to try to study the characteristics curve of the trunk front semi-circular kick (Dollyo Chagi) in the sport of Tae-Kwon-do.

Research Aims:

- Identifying some biomechanics variables of the trunk front semi-circular kick (Dollyo Chagi) skill (displacement - speed - acceleration - Kicking leg push).
- Identifying the angular change of the kicking foot's joints (wrist - Knee - hip) of the trunk front semi-circular kick (Dollyo Chagi).

Hypotheses: The researchers developed a set of questions that corresponds to the descriptive side to study the technical performance characteristics in of the skill on topics:

- What are the mechanical properties characteristics the performance of the trunk front semi-circular kick (Dollyo Chagi) (displacement - speed - acceleration)?
- What is the angular change of the foot joints (ankle - knee - hip) for the skill on topics?

MATERIALS AND METHODS

Research Methodology: The researchers has used the descriptive method as it suit the nature of the search.

Sample of the Research: The sample of the research was deliberately chosen of one player who is world champion in Tae-Kwon-do, gold-medalist in both the World Championships in China 2007 and Denmark 2009, in addition to achieving many of the worlds, international and continental championships and a professional player in the United States of America [4].

Equipment and Tools: The researchers used a video camera and the "Win Analyses" program.

Pilot and Basic Study: Pilot study was conducted in "Mubarak military dome" in Alexandria during holding the World Alexandrians Championships in Tae-Kwon-do, in the championship's first day on 01.02.2008 and then followed by the basic study in the third day on 03.02.2008, was chosen as the best bid for the player to perform the skill for each of the right and left foot in the level of the trunk, face and laboratory analysis of the Physical Education College for men, Helawan University during the period from 10 to 17/11/2008.

Statistical Process: The researchers has used the Excel program for conducting the curves of the research and directly used the results of the used devices and tools used in addition to the percentage rates according to times of performance.

Centers of Mass Submenu calculated (segment centers of mass and body center of mass).

The values for x', y' are calculated on the values for the centers of mass. The first derivative is calculated according to Savitzky/Golay with a kernel of 5. Therefore the first derivative for the first and last two frames of the sequence can not be calculated. So that the second derivative can not be calculated for the first and the last three frames.

The resulting velocity calculated by first calculating the magnitude of the vector and then computing the first respectively second derivative according to Savitzky/Golay.

The impulse p is computed by $p = m * v$. The Ns (Newton seconds) [5].

Table 1: Description of the research sample

Player Name	Age	Height	Weight	Years of Experience
Mamadou Taukina	26 years	205 cm	91 kg	13-year

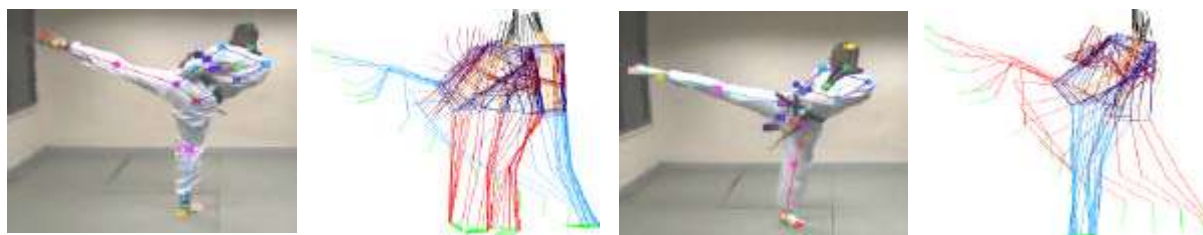


Fig. 1: The trunk front semi-circular kicks skills (Dollyo Chagi)

RESULTS AND DISCUSSION

Figure 1 represents the technical feature of the trunk front semi-circular kicks skills (Dollyo Chagi).

First: the Time Distribution of the Trunk Front Semi-circular Kicks (Dollyo Chagi):

Time Phases and Percentages of (Dollyo Chagi) Skill's Performance: Table 2 and Fig.2 illustrate that the total time of performing the trunk front semi-circular kicks skills (Dollyo Chagi) is equal to the trunk front semi-circular right and left kick as it reached 0.76 s, which reveals the consistency and accuracy of the player's performance and the time equity of performance with both feet.

Concerning the preliminary stage the trunk front semi-circular left kick (Dollyo Chagi) came faster than those of the right foot with a time difference of 0.08 s. in the opinion of the researchers that is due to using the left foot from the front posture (always with the front foot during the counter-attack, which reduces the time of the preliminary stage compared to using the right foot from the back), but the main stage came nearly equal with a time of 0.4 s. of the trunk front semi-circular left kick where the left foot kick was quick with a time of 0.36 s. and concerning the return movement times were equal in both feet with a time of 0.76 s.

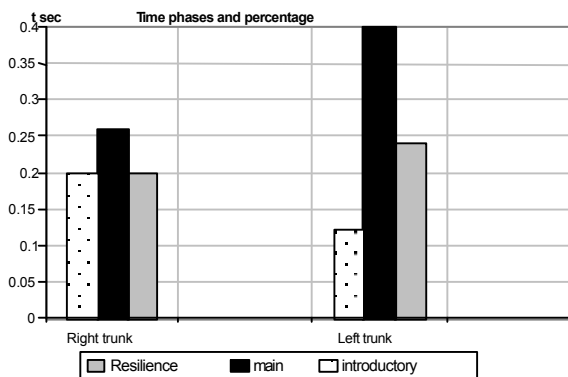


Fig. 2: Long phases of performance

Table 2 and Fig.3 of the analysis percentage of performance stages illustrates that the basic stage acquired nearly 50% of the overall ratio of performing the trunk front semi-circular kicks skills (Dollyo Chagi) due to the nature of the skill which required contraction of thigh, knee and ankle joints to conduct good preparation of the kicking foot that increases the motor energy to take advantage of the reaction such as zipper contraction movement then the full extension of all the kicking foot joints with a streamline whip movement to reach the aim quickly and with great power and accuracy in controlling.

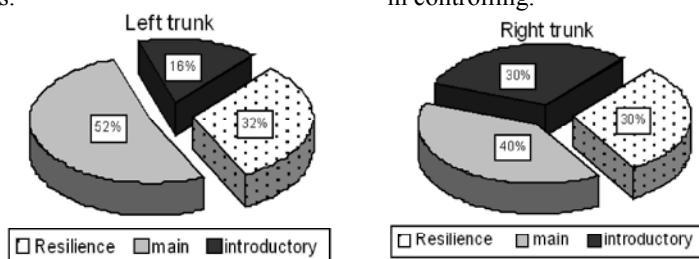


Chart3:Performance stages percentage analysis of research skills

Table 2: Time phases and percentage of performance to Skills (Dollyo Chagi)

Kick forms	Introductory part		Main part		Resilience movement		Total time	
	Time sec	Percentage	Time sec	Percentage	Time sec	Percentage	Time sec	Percentage
Left trunk	0.12	16%	0.4	52%	0.24	32%	0.76	100%
Right trunk	0.2	30%	0.26	40%	0.2	30%	0.76	100%

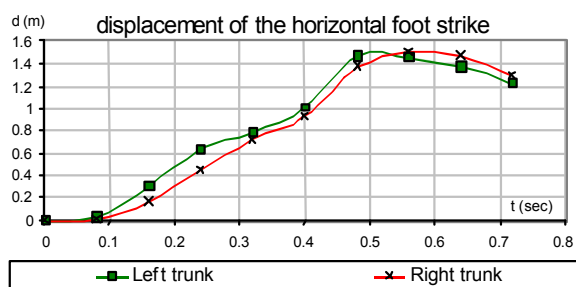


Fig. 4: Displacement horizontal kicking foot

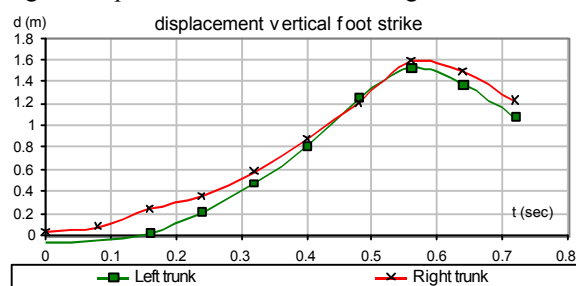


Fig. 5: Displacement vertical kicking foot

Second: the Horizontal and Vertical Displacement of the Kicking Foot During the Performance of the Trunk Front Semi-circular Kicks Skills (Dollyo Chagi):

Table 3 and Fig.4 of the horizontal displacement amounts of the kicking foot during the performance of the trunk front semi-circular kicks skills (Dollyo Chagi) illustrates that the longest horizontal displacement was for the trunk front semi-circular right kick, which achieved a distance of 1.505 m. with a time of 0.56 s. where the same kick with the left foot achieved a displacement amount of 1.477 m. with a time of 0.48 s. with a very small difference 0.028 m. that was at the end of the main stage while the crashing moment, meaning that the kicking metatarsus has moved forward to accomplish the motor duty to overcome the opponent's defensive movement by returning back and also to the circumstances of performing the kick to the trunk, which requires conducting long horizontal displacement to reach the opponent's body.

The player's anthropometric measurements especially the lower limb of 111 cm. has helped to reach optimal and effective performance when performing the kicks, especially the trunk front semi-circular kick, where it represented more than 90% of the player's effective skills and techniques in all his matches whether in the world championship China 2007 and the world championships in Denmark 2009 [4].

Through Table 3 and Fig. 5 of the vertical displacement amounts of the kicking foot during the performance of the trunk front circular kick skills

Table 3: The displacement of the horizontal kicking foot during the performance of research skills (m)

Time	Right trunk(m)		Left trunk(m)	
	Horizontal	Vertical	Horizontal	Vertical
0	0.002	0.033	0.002	0.048
0.08	0.016	0.077	0.037	0.036
0.16	0.174	0.245	0.314	0.021
0.24	0.452	0.359	0.635	0.22
0.32	0.721	0.577	0.793	0.48
0.4	0.924	0.876	1.017	0.822
0.48	1.377	1.209	1.477	1.251
0.56	1.505	1.597	1.461	1.531
0.64	1.476	1.482	1.378	1.384
0.72	1.3	1.232	1.241	1.089

Table 4: Velocity resultant for kicking foot during the performance of research skills (m / sec)

time	Right trunk	Left trunk
0.08	1.689	2.26
0.16	3.25	3.935
0.24	4.052	3.938
0.32	4.484	3.741
0.4	5.382	5.546
0.48	6.386	6.764
0.56	1.489	1.736
0.64	2.833	3.739
0.72	2.199	0

(Dollyo Chagi) illustrates that the trunk front semi-circular right kick achieved a horizontal displacement of 1.597 m. with a time of 0.56 s. where the same kick with the left foot achieved a horizontal displacement amount of 1.531 m. within the same time of the right foot of 0.56 s. with a very small difference 0.066 m. which verifies the extent of accuracy when performing the skill with both feet. Moreover, this long displacement with such short performance time along with the amount of accelerating speed and kicking foot mass leads to an amount of movement significantly affects the opponent which is consistent with the Tae-Kwon-do international regulations, where slow, weak or normal effect kicks are not counted and also stated that a kick to the head deserves three points which increases the rate of its implementation [6].

Third: the Velocity Resultant of the Kicking Foot During the Performance of the Trunk Front Semi-circular Kicks Skills (Dollyo Chagi):

Table 4 and Fig. 6 of the velocity resultant amounts of the kicking foot during the performance of the trunk front semi-circular kicks skills

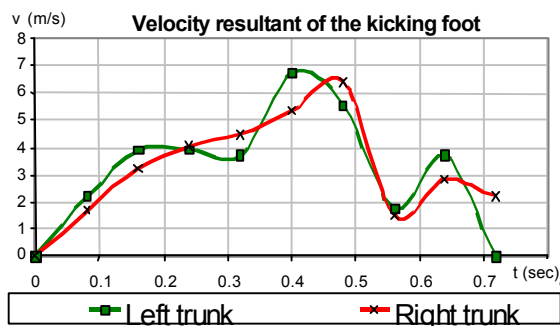


Fig. 6: Velocity resultant for kicking foot (m / sec)

(Dollyo Chagi) illustrates that it ranged between 6.38 m/s for the right foot, 6.66 m/s for the left foot at the time of 0.48 s. These amounts were recorded prior to the crashing moments of all types of kicks, which are a high- Velocity along with the horizontal and vertical displacements contributes to provide suitable quantities for an increasing acceleration of the metatarsus.

Velocity along to mass reveals the composite of movement amount, which leads to provide high amount of energy at the end of the main stage for the kick to increase the impact on the opponent. Velocity with strength lead to the emergence of another compound is power or explosive power of the effective impact in the crashing moments, where speed of all types is an important physical component in combat sports in general and Tae-Kwon-do especially, because of the nature of performance and the changing situations in the match requires performing in the possible shortest time as well as a Velocity of return where the attacker may turn to defender during the performance of kicks in a part of a second.

The motor speed is one of the qualities that characterize a Tae-Kwon-do player of high-level standard, due to performance method within the match and its requirements of performing the kick at full speed and as possible strength. The successful motor speed during the performance depends on the choice of proper timing for performing the skill, which is implemented through deception and prevarication movements both in defense and attack which is performed by the player during the match to detect a suitable gap of the opponent where he can execute the required skills. Moreover, during the counter-attack the player needs the speed to reach an appropriate defensive position to avoid the opponent's attacks. As well as when confronting the opponent (response) by performing opposite kicks like the front semi-circular kick (Dollyo Chagi) through counter-attack when the opponent performs different offensive skills (activator) [7].

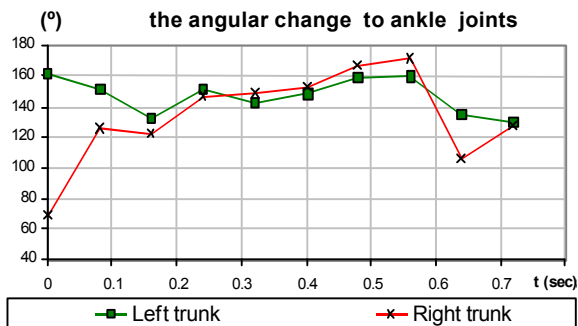


Fig. 7: Angular change to ankle joint (°)

Table 5: The angular change to some joints kicking foot (°)

Time	Right trunk (°)			Left trunk (°)		
	Ankle	Knee	Hip	Ankle	Knee	Hip
0	70. °	166.9°	94.9°	162.5°	176.4°	102.9°
0.08	126.5 °	151.4°	86.5°	152.°	147.2°	93.9°
0.16	122.5°	119.5°	103.3°	132.9°	116.9°	84.2°
0.24	148.0°	97.9°	115.9°	152.6°	100.1°	105.6°
0.32	148.7 °	66.5°	130.1°	142.9°	79.2°	120.1°
0.4	152.8 °	61.5°	143.4°	148.4°	57.3°	149.3°
0.48	167.8 °	179.7°	144.7°	159.°	178.2°	149.8°
0.56	171.7°	166.7°	147.2°	160.3°	168.3°	151.1°
0.64	105.2 °	108.2°	144.5°	135.5°	103.2°	145.5°
0.72	128.2°	77.7°	139.6°	130.4°	63.3°	141.2°

Fourth: the Angular Change of Some Joints of the Kicking Foot During the Performance of the Trunk Front Semi-circular Kicks Skills (Dollyo Chagi):

Table 5 and Fig.7 of the angular change amount of the ankle joint of the kicking foot illustrates that it recorded 171. 743 ° for the right foot and 160. 038° for the left foot at the crashing moment, this angle is not satisfactory but could be attributed to repeated injuries of this joint like sprain ankle when kicking or landing on the ground after performing a flying kick. Therefore attention and required precautions must be conducted to protect this joint to reach full extension of the ankle bones. the right foot angle was satisfactory as it makes the joint in the form of a spoon to make greater room section for the ankle with the metatarsus when contacting with the opponent trunk and conducting the greatest possible impact resulting from the amount of the acquired capital movement from the foot mass, which represents 12% of total body weight, as well as high speed in preparation for the kick with the presence of this angle as it protects the joint from injuries as a result of the full extension. All the above factors may lead to a knockout that may end the game or at least scores three points according to the modern amendment to the Tae-Kwon-do regulations on 2009.

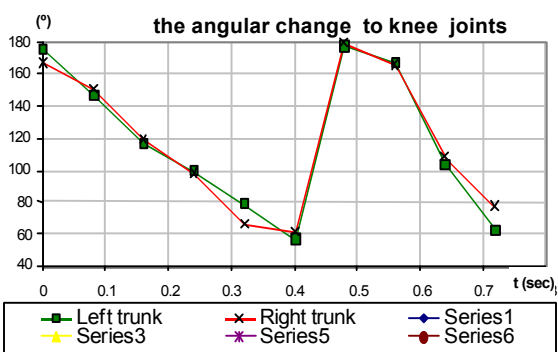


Fig. 8: Angular change to knee joint (°)

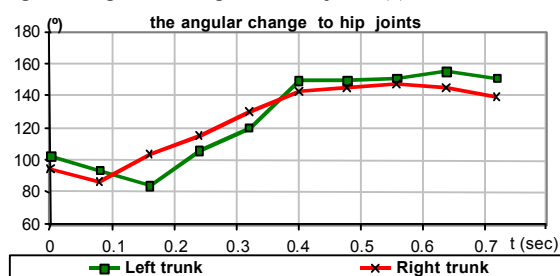


Fig. 9: Angular change to hip joint (°)

Table 5 and Fig.8 of the angular change amount of the knee joint of the kicking foot illustrates that the changing ratio within the crash moment ranged between 179.73 ° and 178.201° with a different of 1.52° which is an excellent rate for achieving the further and higher horizontal and vertical distance of the kicking metatarsus to reach its aim. The knee is considered the Tae-Kwon-do kicks performance base.

By observing Table 5 and Fig. 9 of the angular change amount of the hip joint, illustrates that it ranged between 147.2° for the right foot kick and 151.08° for the left foot kick with a time of 0.56 s. with a different of 3.12° at the end of the turn stage.

Fifth: the Pushing Amounts of the Kicking Foot During the Performance of the Trunk Front Semi-circular Kicks Skills (Dollyo Chagi): Table 5 and Fig.7 of the angular change amount of the ankle joint of the kicking foot illustrates that it recorded 171. 743° for the right foot and 160. 038° for the left foot at the crashing moment, this angle is not satisfactory but could be attributed to repeated injuries of this joint like sprain ankle when kicking or landing on the ground after performing a flying kick. Therefore attention and required precautions must be conducted to protect this joint to reach full extension of the ankle bones. the right foot angle was satisfactory as it makes the joint in the form of a spoon to make greater room section for the ankle with the metatarsus when

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Fifth: the Pushing Amounts of the Kicking Foot During the Performance of the Trunk Front Semi-circular Kicks Skills (Dollyo Chagi): While attacking, Tae-Kwon-do sport mainly depends on the right and left feet whether in when positioning on the ground or flying in the air.

Its one of the most difficult performances, where showing strength comes through muscular effort in a particular direction to reach a reaction in the opposite direction which always happens when positioning on the ground, but during flying strength reaction comes through the related-lower limb body parts such as the pelvis and trunk, which requires high training capacity, agility and smooth motor uninterrupted transfer of the strength waves to reach the ends of the lower limb and then speed back to defense posture again. Therefore, pushing has the importance and meaning in the disruption process of the skillful performance as an important kinetic variable of the front semi-circular kick skills (Dollyo Chagi). By reviewing Table 6 and Figure 10, we will find that the pushing amounts ranged between (8.825 Nm/s) for right-foot pushing at the time of 0.48s. and (10.662 Nm / s) for left-foot pushing at the time of 0.4s and the pushing preparation process came gradually from the beginning of performing the skill from the ground and then depending on motor transport from the positioned foot to reach the push peak before the crashing moment with the opponent.

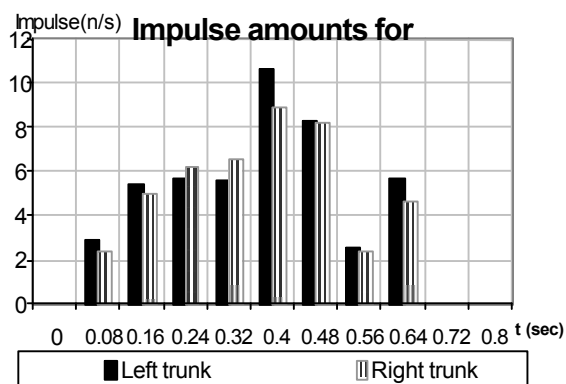


Fig. 10: The pushing amounts of the foot strike (N/ s)

Table 6: The pushing amounts of the kicking foot(N/s)

Time	Right trunk	Left trunk
0	0	0
0.08	2.414	2.886
0.16	4.977	5.444
0.24	6.197	5.599
0.32	6.505	5.543
0.4	8.824	10.662
0.48	8.225	8.354
0.56	2.385	2.455
0.64	4.589	5.632
0.72	0	0

That distinguishes the high and powerful technical performance of the player Mamadou Tuketa. Performing kicks strongly to the trunk area is consistent to the amendments of the international regulations by using the electronic Hugo, which requires the availability of legal percentage of strength to score the kick, this ratio varies according to various weight categories of the game [3].

Abdel-Hamid [8] indicates in the second principle of the five biomechanics principles that the effect of all powers participating in movement and causing the increased motion must end in the same time, meaning concentration and assembly in a single moment is the moment of crash.

CONCLUSION

- The equity of the total time of performing the skills was in favor of the right and left front semi-circular kick (Dollyo Chagi) where it reached 0.76 s and that means that there are no statistical differences in the kick's performance times.
- Percentage of the main stage scored the highest percentage nearly 50% of the total percentage of performing the trunk front semi-circular kicks skills

(Dollyo Chagi) with a difference of 5% between performing with the two foots to the trunk, while exchanged the increase of the preliminary time with a difference of 10% in favor of the left kicking foot and 5% in favor of right kicking foot in the return stage.

- The amounts of the longest horizontal displacement of the kicking metatarsus was for the right and left trunk front semi-circular kick (Dollyo Chagi) by 1.505m for the right foot kick and 1.477m to the left foot kick, with a difference of 0.028m represents a percentage of 1.86% which is a small percentage indicates to the lack of significant differences between the two feet when performing the kick.
- The amounts of the longest vertical displacement of the kicking metatarsus was for the right trunk front semi-circular kick (Dollyo Chagi) by 1.597 m while the left foot kick achieved a vertical displacement of 1.531 m, with a difference of 0.066 m which is a very small difference that indicates the extent of accuracy when performing the skill with the two feet and represents a difference ratio of 4.13% which is an acceptable ratio indicates to the player's neuromuscular when performing the kick with the two feet.
- The highest rates of total speed of the kicking foot during performing the trunk front semi-circular kicks skills (Dollyo Chagi) were extremely similar. Table 4 illustrates that the difference between the obtained speed when performing the kick with both feet to the trunk were 0.27 m/s near the end of the main stage in favor of the left foot with a percentage of 4.05% which is an acceptable difference in the obtained speed. The researchers return that to the front posture of the left foot making it easier to disperse more quickly from the back position of the right foot.
- The largest rate of the kicking foot ankle's angular change during the performance of the trunk front semi-circular kicks skills (Dollyo Chagi) ranged between 171.743° to 160.038° with a difference of 11.7° with a ratio of 6.8% which is a high percentage refers to the need of studying the causes of the differences between the two kicks of both feet, which might be due to an injury in the left foot ankle reduced the extension degree of the hip joint in good manner, this is consistent with Seong Hong 1985 as he referred that when performing kicks like (Optullio Chagi and Te Dollyo Chagi) the kicking leg must strike in a vital way with a wide range to achieve the aim of the kick [5].

- The largest rate of the kicking foot knee joint's angular change during the performance of the front semi-circular kicks skills ranged between 179.73° and 178.201° with a difference of 1.52° with a ratio of 0.84%, which is an excellent rate for achieving the further and higher horizontal and vertical distance of the kicking foot.
- The largest rate of the hip joint's angular change during the performance of the trunk front semi-circular kicks skills (Dollyo Chagi) ranged between 147.2° to the right foot kick and 151.08° to the left foot kick at 0.56 s. with a difference of 3.12° with a percentage of 2.06% and it is also considered as an obvious indication of the high training standard for the international player "Mamadou Tuketa" and the availability of the flexibility element, especially for the hip joint as the front semi-circular kick can not be performed up to the desired aim without the availability of the flexibility element, especially in the joints of the thigh and hip, which confirmed by Keith and Robbins [9] that in order a Tae-Kwon-do player reaches the advanced level, learns and master any technique must have had the flexibility element .
- The kicking foot pushing amounts during performing the trunk front semi-circular kicks skills (Dollyo Chagi) ranged between 8.825n/s. for right foot pushing and 10.662 n/s. for left foot pushing with a different of 1.83 n/m. represents a percentage of 17.22% which is a relatively large ratio may be due to the existence of compatibility differences of motor transport operations between the body parts when performing the kick.

Recommendations:

- Establishing the results of the recent study as a reference for conducting comparisons between the international player Mamadou Tuketa and other players performing the same skill as an option to evaluate the operations of determining the physical and skill level progress[10].
- Baying attention to characteristic curves of the skillful performance of the trunk front semi-circular kicks skills (Dollyo Chagi) as the most important skills of Tae-Kwon-do, as it illustrates the accurate defects of the performance in the paths of displacement, speed and pushing through the different technical stages for both feet and therefore correcting the stage which represents problems in the performance [11].
- Depending on the kinetic analysis to identify the improvement rates of the Tae-Kwon-do player's skillful performance.
- Emphasizing on applying similar studies for Tae-Kwon-do players in the developed and international countries in different weight categories to take advantage of modern technologies in describing the distinguished skillful performance.
- Try to reach the less difference between the variables of both feet in the sport of Tae-Kwon-do[12].
- Conducting more studies aims at identifying the mechanical properties of back straight and back-circular kicks, as well as conducting comparisons between the Tae-Kwon-do different skills [13].
- Conducting studies aims at identifying the working muscles and its contribution rates in the different Tae-Kwon-do skills to focus during physical training as well as for injuries prevention [14].

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