

Motion Analysis Of The Front Kick Technique Of Pencak Silat Athlete

Awan Hariono^a, Tandiyo Rahayu^b, Widiyanto^c; Japhet Ndayisenga^d

^{a*,c} Faculty of Sports Science, Yogyakarta State University

^b Semarang State University

^d University of Burundi, Institute of Physical Education and Sports

email: ^aharionoawan@yahoo.com; ^btandiyorahayu@mai.unnes.ac.id
; ^{c*}widi@uny.ac.id; ^dndayisengajaphet@gmail.com

Abstract

The objectives of this lookup were deeply to analyze the works of front kick in the perspective of sports biomechanics. The research sampling was 4 pencak silat from Yogyakarta Special City. This research was an explorative study with survey method. Data collection was recording of the front kick technique movement. Moreover, the images were taken from all viewpoint namely proper side, opposite side, and rear side. Then, the statistics were analyzed using Dartfish Prosuite and Kinovea Software in order to attain in detail consequences. The Result showed that: (1) front kick performance in Readiness Phase extent from knee flexion angle, the rear leg segment tends to be smaller than the front, except subject 1, with the result more efficient for further motion; (2) the performance of front kick in the split second before take-off until the impact is inefficient. Those because of the head is not upright, fulcrum inclined tend in the same direction with the trotters strike; (3) front kick performance in follow through is still inefficient. In conclusion Pencak Silat athlete were still need to improve their techniques..

Keywords: analysis, front kick, Pencak silat

1. Introduction

The basic principles of Pencak Silat Tanding category is gaining value with an attack and protection. Values in Pencak Silat Tanding category obtained when a fighter can perform the technique punches, kicks, and may enter in field goal defense and not blocked by an opponent. To be able to attack and protection, the acquisition of skills motion the basic techniques of Pencak Silat that are urgently required.

The basic techniques of Pencak Silat can be divided in 6 series, namely: (1) horses; (2) the attitude of the tide; (3) the measure; (4) technical protection (defense and avoidance); (5) attack techniques (punches, elbows and kicks); and (6) kickback/drop (Kotot, 2003). The six categories, technical punch, kick techniques, and techniques fall/kickback are techniques used to obtain values in Pencak Silat tanding category. Therefore, the mastery of technique punch, kick techniques, and techniques drop/shock are needed, so a fighter can achieve optimal performance. Three methods for amateur fighter was not going on at the same time, however it was taken primarily based on priority of using according to the need of the skill. According to Agung Nugroho (2005) basic strategies that can be used to achieve a value, about 47% are predominantly used in Pencak Silat Tanding class is the kick technique. Therefore kick was the dominant technique used during the game, the technique is of particular concern during the training process. The kinds of techniques in Pencak Silat kicks, including front kicks, crescent kick, kick back, and front kick. The technique is an attempt to kick or processes

using both defensive and attacking leg to earn so fast. Kick skill is several applied as a primary gun to attack and to defense to score in the contest. Given its importance, the technical implementation kicks in the competition must be effective and efficient. A kick technique is described to have the effectiveness and efficiency of movement when it can be done quickly and produce value as expected.

The technique can obtain the kick when entered in the target field using the power and unrestricted by catch or parry the opponent. But the fact is different perceptions and view points jury to kick technique that uses power often result in a different assessment. Therefore, the hardness of the sound and the effects after the impact of the kick techniques when the target can be used as an indicator that a kick made it using power. Based on this observation, the front kick is the dominant technique used in Pencak Silat fighting serry Because of the kick techniques are considered to have an advantage in producing the sounds and effects of the after math of the impact so it is advantageous to obtain a value for the match. Therefore, it is necessary to analyze the motion of the kick so that efficiency and effectiveness.

2.Literature Review

Pencak Silat is originally from Indonesia. PB IPSI (2003) stated that. Pencak Silat is the culture of Indonesia which aimed to deffense and protected the existance and integration on the environment and natural surroundings as well as to achieve the harmony of life in order to increase faith and piety to God.

In line with the above O'ong Maryono (1999) argued that Pencak Silat is the attack-defense movement organized according to the system, time, place, and with the climate of mutual maintain the honor of each gallantly and did not want to hurt the feelings which are closely related the human conscience. That is, that although the Pencak Silat involves physical element but still adhere to ethical values and aesthetics as well as referring strictly to the teachings of God Almighty. Thus the Pencak Silat are closely related between the physical and spiritual aspects of the terms.

Pencak Silat matches including individual sports that require physical ability, technique, tactics, mental and individually, so that every fighter should have some of these components to support the achievement. In an effort to gain match point in Pencak Silat can use a variety of techniques, including: punches, kicks, falling / kickback.From some of these techniques are most often used to gain point is the kick technique. According to research conducted by Agung Nugroho (2005), the percentage of the types of techniques used fighter during the game (3 innings) in order are as follows: (1) kick technique by 44%, (2) stroke technique by 33%, (3) techniques to catch falling by 14%, (4) the technique fallen by 5%, (5) kick technique with protection by 3%, and (6) a punch with a protection technique by 1%.

2.1.The Techniques

The basic concept to kick skill in athe game have to be with attitude. The knee has to be risen at the maximum and the lower leg must be lashed slowly, the hips accompany the movement and legs pivot, thus getting maximum speed, apart from the need to be considered aspects related to health, namely: The joints must be protected from the severe force from the activities. The knee is the responsible center of cracking while the kicking. Excessive stretching in question is a condition where the lower leg swings to achieve the target. Such conditions commonly experienced fighters during a kick without the use of targets that will experience excess friction in the joints which will increase the production of synovial fluid in the knee joint. If it happens repeatedly, the production of synovial fluid along with frequent technique performed with the right not to be decreased.The techniques are:

2.1.1.Front Kick

Straight front kick is an attack using the foot and leg, the track towards the front with the position of the body facing forward and toward the target solar plexus. According to R. Kotot Slamet Hariyadi (2003), many of the Pencak Silat's master teach this technique earlier.

2.1.2.Crescent Kick

Crescent kick is a kick down the tracks that resemble a crescent or half circle with directions to inside. The crescent kick impact at the time of impact is part of the instep.

2.1.3.Side Kick

Side kick is a technique that is done towards, the front kick to the body posture sideways. The impact is when doing side kick is on the heel or the outer side of the foot and target the entire field goal.

Motion Analysis Of The Front Kick Technique Of Pencak Silat Athlete

2.1.4 Rear Kick

Rear kick is the most difficult implementation. The trajectory kick straight to the rear with his back to the opponent postures. The impact of the rear kick at the time of impact is on the heel or the outer side of the foot.

2.1.5 Front Kick

Through various kind of kick techniques used in Pencak Silat matches, front kick technique has all the high quality like efficiency and effectiveness of strong action. Front kick is a kick done laterally with the impact on the heel, legs, or the outer side of it. Front kick technique is more effective, because this technique has a parabolic trajectory like motion that would generate maximum speed and the furthest point that can be achieved. Apart from that, the front kick technique has a high degree of balance, due to the projected center of gravity and wide field generated fulcrum. So the next kick technique often used in every game.

Impact-based targeting, front kick techniques can be categorized into two types, namely tendangan gajul and tendangan jejag. The impact of tendangan gajul using the base of the toes while tendangan jejag using heel. As according to its function, front kick techniques can be divided into two, namely: a kick to attack and kick to survive. Front kick attack was applied to push towards the opposite' field goal. While the front kick to survive is a kick that is used to reply or provide attack after giving the opponent the attack or to stop the movement of the opponent.

Front kick technique to attack can be done in various ways, including: (a) a kick forward on legs that are behind, (b) using the front kick leg in front. In this research the skills were several applied on the next kick front kick kind of scoundrel to attack on legs that are behind. The series of kick techniques ahead scoundrel motion to strike on legs that are in front, carried out through several stages: the attitude of the tide, the implementation of the

2.2. Readiness Phase

Attitude phase is the basic attitude for each techniques in Pencak Silat matches. According to Agung Nugroho (2001), the attitude is the attitude standby phase to defend or attack patterns and performed at the beginning and end of the range of motion. Attitude phase can also be interpreted as an attitude to face the opponent's tactics were patterned attack or greet (Johansyah, 2004).

Many readiness steps in Pencak Silat fighting. To make it easier to learn the phase, then PB IPSI standardize the attitude of the tide in the eight categories. As for the attitude of phase that have been standardized by PB IPSI, is as follows: (1) attach one; (2) phase of two; (3) phase of three; (4) phase of four; (5) phase of five; (6) phase of six; (7) phase of seven; (8) phase of eight. Of the eight readiness phase is standardized by PB IPSI, the most appropriate phase attitude to front kick (scoundrel) is the attitude of the phase, two phase attitude, the attitude of phase 3, and six phase attitude. The aim of this research was analyzing of the movement of the front kick skill scoundrel to attack, then the attitude of phase that will be used is the attitude of the post.

2.2.1. Implementation

Implementation of the subsequent section of the manner kick scoundrel motion carried out by fighters. At this stage significantly affect the success of a kick to earn factors at some stage in the game. Therefore, at this stage should be done as successfully as possible. Efficiency at the time of this motion is influenced by means of a number of indicators, including: (1) the motion of the legs that work, (2) the kick way, (3) the function fulcrum and head, (4) the position of the arm, and (5) impact.

2.2.2. Follow Through

The foot on which the movement revolves and the center of the body weight are the angles of the continuation of this research. After striking a kick the balance is effected by the body following the participation of the opposing forces Imam Hidayat (1999) a body in balance if is only if it can maintain the position for a long time even if there are influences

2.2.3. Biomechanics Principles of Front Kick Techniques

Sports biomechanics is the lookup of nternal and external action to perform actions in the human body (Putut Marhaento, 1998). Some theory said that it is limited to the application of to the motion of human body or thing. It is a party of physics that deals with force and motion created by force (Soedarminto, 1992). Below are biomechanical laws pencak silat's front kick:

2.2.4. Acceleration

The application of acceleration during the forward kick is determined by: (1) the start of the acceleration immediately after takeoff, (2) the use of force for the kick, (3) when power is generated, and (4) the length of the leg. Acceleration is the change in velocity per unit time (Putut Marhaento, 1998). The acceleration technique in the forward kick occurs when the foot has started to take off until just before the impact. Acceleration is done to gain additional strength to increase the amount of momentum when hitting the target. The law of acceleration is often referred to as Newton's second law which reads: "The acceleration received by an object is inversely proportional to the force that caused it". Newton's second law is stated in the following equation::

$$a = F / m \quad \text{atau} \quad F = m \cdot a$$

2.2.5. Center of Gravity and Balance

The implementation of the motion of the front kick approach is a complicated series of actions performed simultaneously. The success of the front kick technique is strongly influenced with the aid of environmental factors: the mattress, the target and the pressure of gravity. During the front kick, the area of the body's middle of gravity will change with every step of its implementation relying on the mind-set and affect the movement. The location of the lower core of gravity of the body, the most balanced and stable, but it will take a higher pressure to start the movement. The front kick in this learn about is a kicking method used for attacking that requires excessive speed in order to keep away from a tough opponent. The step movement on the the front kick method of implementation will determine the result. of the kick technique. The faster the step is taken, the less complicated the competitor will be to launch. (Putut Marhaento, 1998).

2.6. Lever

The benefit of lever mechanicity is obtained by the use of lever arms. The small force one can lift large loads without spending a lot of energy. the acceleration of the movement is conditioned by a violent sway. Therefore the effect on the target is produced by the application of the foot mechanism of pencak silat player. The result of the kick is a result of its position and the swing of the attacking foot.

2.7. Force

The force is characterized by 4 essential elements namely the direction, the speed, the intensity and the weight of application. Newton's law said it well that when a player exerts a zero force on an object, there is no result or the object does not move. The pencak silat player will use Newton's law principle to execute a giant, strong kick. It will be a question of mobilizing all the qualities of the force as mentioned above at the start.

2.8. Momentum

The surge of force results from mass and speed. For a pencak silat player the force used during the execution of the movement must be done in such way that the result gives the great amplitude. The momentum is a very important element in the implementation of the kick of a pencak sila.

3. Methods

This study was conducted on 6 September 2014 located in Hall Bela Diri FIK UNY, the research subjects were all fighters sparring PPLM DIY category that consists of 4 athletes. The research design used in this research is descriptive exploratory. Descriptive exploratory research is a study that aims to find new relationships contained in a vast and complex problems (Mardalis, 2008). The method used in this research is the survey. The instrument used was kicked tug using the technique of front kicks. Each athlete doing front kick technique toward the target, starting with the attitude of pairs up with advanced motion (follow through). The tools used in the form of handycamera, threepod, and tug. At each technique front kick consists of several stages, namely: (1) The first stage, which is when do attitude pairs, (2) the second stage, i.e at the time of movement, and (3) the third stage, ie at the time the next motion (follow through). In order to provide an overview of the stages at the time of the next kick analyzed in this study, we used the grating instrument that has been validated by experts/expert. While the data collection was film of front kick technique scoundrel done all Pencak Silat athletes PPLM members DIY. The image is taken from a different direction, namely the front right, front left and rear. Researchers took pictures accompanied by experts so that the observations can be produced valid data.

After the data is collected, the next step is to analyze the data so that data can be concluded. For the purposes of data analysis, researchers assisted experts. Data were analyzed using analysis software system

Motion Analysis Of The Front Kick Technique Of Pencak Silat Athlete

Dartfish Prosuite. Handy camera used to take pictures connected to a laptop that has been installed Software Dart Trainer. Prosuite Dartfish program offers a complete range of video analysis equipment among others *simulcam* and *stromotion* which makes the stages of movement can be seen clearly and in detail, especially the front kick technique. Then the data that has been obtained included in the analyzer to determine and give angles and possible errors that would hinder the effectiveness of the technique front kick.

4.Results

The data in this research was the performance of the front kick with the best leg from the obtained subject. Tug front kick test is performed. To count on the incidence of bias towards the outcomes of the analysis, it was given manage of the factors that effects lookup outcome, such as: height, weight, and long legs. Results from statistics collection to 4 athletes can be viewed from Table 1 below:

Table 1. Anthropometric Measurements

No.	Subject	Sex	Height (cm)	Weight (kg)	Limb length (cm)		
					Up	Down	Overall
1	SH	male	171	56	50	41	91
2	GTWP	male	166	54	55	42	97
3	FWP	male	183	84	56	44	100
4	LK	female	164	57	50	42	92

The table above shows that the technique of movement is evaluated by analyzing the angle performed by the knee during the flexion, but also the value of the angle performed by the elbow during the kick is also calculated during its flexion. bending. The result showed that the preparation phase was quantitatively and qualitatively consistent

4.1.Readiness Phase from Left Side

The right leg was the most favorable for all the competitors at the time of the execution of the kick. From the biomechanical point of view the movement procedure can be: (1) the preparatory phase was correct for all participants, (2) the arm segments are classified as follows: right arm in forward position, palm at the top of the waist , elbows in can flexed or bent but there is the parallelism of the feet with the latter, (3) The left arm is spread out in front of the chest with an elbow flexion of less than 90, (4) the center of gravity must be well placed in such a way as to maintain balance.

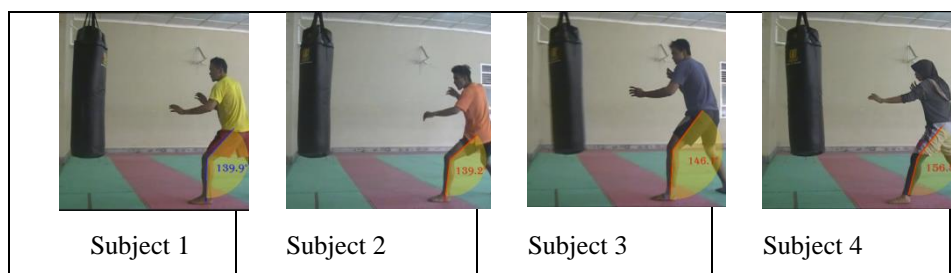


Image 1. Readiness Phase from Left Angle

4.2.Readiness Phase from Right Side

The results of the right-side front kick are characterized as follows: (1) the eyes of all participants are on the target, (2) The core is loose on the target except for players number 7 and 8, (3) the feet are flat on the ground except number 8, and finally the distance between the supports was different varying between 30 and 56 cm

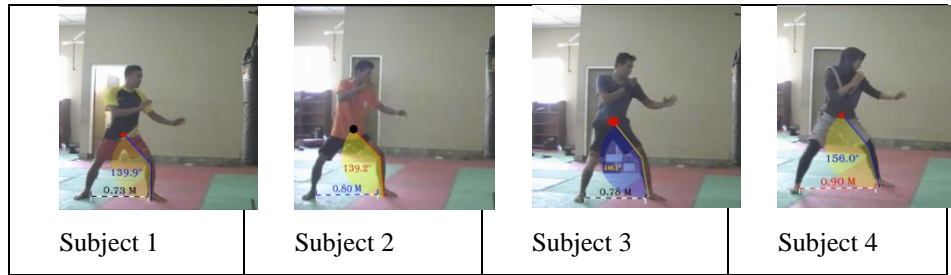


Image 2. Readiness Phase from Right Angle

The results capturing of the back front kick technique, can be explained as follows: (1) All subjects were slightly hunched the core on this phase; (2) Position both subject feetholdwere in a straight line towards the target, except in subject 2; and (3) The amount of angle knee flexion of the back leg were different between one subject to another subject (between 131° - 158°).

The consequences shooting of the back front kick technique, can be defined as follows: (1) All participants were slightly hunched the core on this phase; Two players find challenges to orient themselves towards the target. players number 2 and 3 have no problems, an observation that was made is that the angle (between 131 ° and 158 °). of flexion movement is different which makes for different results. the optimum angle is a factor that can be influenced by success.

4.3. Readiness Phase from Rear Side

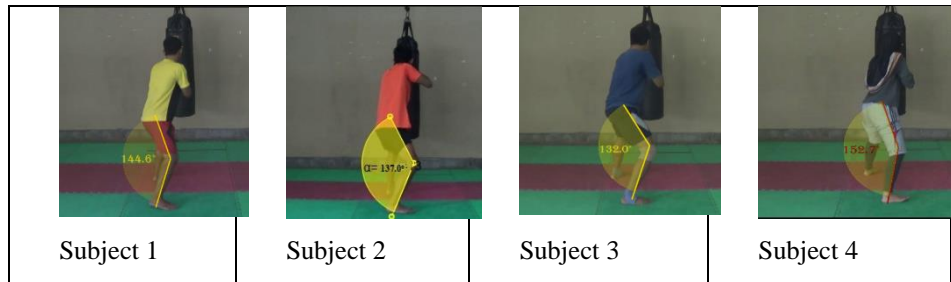


Image 3. Readiness Phase from Rear Side

Observations exhibit that the positions taken with the aid of the head, arms, legs and the positioning are not very good in the training stage the players have less orientation but focal point on tailor-made. the middle of gravity and attitude prefer the pencakilat participant to achieve the goal. However, when viewed from the togok role which tends to bend, the motion of the test is hampered due to the fact the area of the center of gravity will shift to the center and the challenge tends to produce a stable position. The favored motion requires stability and sufficient electricity for the effects to be good. In addition, the knee flexion attitude on the total situation is shown successfully and correctly which impacts the movement of the steps. This is illustrated with the aid of comparing the magnitude of the attitude between the fairly small flexion of the forefoot knee and the hind leg of the knee.

5. Discussion

5.1. Readiness Phase of the Front Kick Technique

Readiness Phase in the Pencak Silat is a simple approach that have to be mastered by means of every pesilat. In the Pencak Silat Tanding Category, the attitude of pairs (ready position) is the initial manner by pesilat earlier than the assault or defense action technique in a sequence of simultaneous movements. The mindset of pairs decide the success of action technique to be carried out by using pesilat. Therefore the use of the manner associated to engineering action layout that will be carried out through pesilat.

Readiness Phase in a in shape of Pencak Silat is carried out in accordance with the strategies to be used. To do a front kick method ideally the usage of six pairs attitude, the phase of pairs is performed with the pivot leg is in the the front are in a straight line with the pivot leg is behind. To gain speed, point weight have to be on the pivot leg is in front. To the front knee need to be barely bent even though now not allowed to be too low. Therefore, the knees are bent too low will lead to secure position pairs mind-set so as to increase the inertia of the body. As a result, the preliminary motion to do a side kick tends to be slower. At this stage of the attitude of put up there are some things that influence, namely: (1) the eye of the target, (2) the function of the arm, (3) the function of the maintained upright (4) perspective of knee flexion ahead, (5)

Motion Analysis Of The Front Kick Technique Of Pencak Silat Athlete

the attitude knee flexion knee back, (6) the distance between the pivot leg, and (7) the placement of the pivot leg.

Based on the consequences of shooting in addition analyzed the usage of Dartfish Prosuite and Kinovea suggests that the subject's eyes all on target at the time of tide attitude. To role the rear arm, nearly all of the subject's arm was once positioned in the front of the chest with the elbows barely bent. As for the forearms all located at waist stage and slightly bent at the role parallel to the front legs.

The evaluation of knee flexion perspective of the front suggests that: (1) the front knee flexion perspective is the smallest is 139.2° shown via the situation two and the greatest angle 156.0° is displayed through the challenge four The subsequent essential knee flexion attitude of the subject 1 is 139.9° knee flexion perspective whilst the massive the front of the challenge 3 is 146.1° . The outcomes of the evaluation at the back of the knee flexion perspective confirmed that: (1) behind the knee flexion perspective is the smallest is 132.0° shown by way of the subject three and the biggest angle 152.7° is displayed by the situation 4 The important knee flexion perspective behind the issue 1 amounted to 144.0° , while giant knee flexion attitude in the back of the difficulty 2 is at 137.0° . The quantity of knee flexion attitude largely determines the overall performance of the implementation rear facet kick technique. The increased the attitude of knee flexion rear furnish benefits for the fighters to do the first step. Therefore, magnificent location center of gravity tends to be imposed on the legs abutting the the front so that the situation of the fighters tend to be in a state of unstable equilibrium when the initial mind-set (pairs). Thus the concern does not require a large force for take-off at the foot of attack.

5.2. Impact Phase of the Front Kick

Impact is the stage the place foot strike touch in the goal field. The success of the approach front kick is decided at this stage. At this stage of the have an effect on ideally a view toward the target position, the role maintained the fulcrum and head erect, and the balance in a secure condition so it is now not convenient to fall. Power generated at the time of have an effect on is acquired from the motion of every physique segment. The movement of the body segments starting from the rotation of the foot pivot outwards and pull your left arm towards the rear of the bottom which is observed round the hips to the left. Changes in pivot foot can be considered in the picture quit position impact. At this stage of influence there are some that affect the front kick, the head position, arm position, fulcrum, hip rotation and the direction of the track. From the four subjects seem that all eyes have been on target. However, when viewed from the role of the head, it appears that the problem two and 4 are likely to bow your head whilst the difficulty 1 and three have a tendency toward the back. In addition influenced by way of the magnitude of the pressure created on stomping before the impact, the role of the subject's head is additionally appreciably influenced by way of the high have an effect on to the subject purpose feet. The higher the affect made to the target area will purpose the position of the head inclined toward the rear and unable to be maintained in an upright position.

This is in accordance with Newton's third regulation which says "If two objects interact, the fashion of which is held with the aid of one object to some other object equal magnitude and opposite direction". That is, the higher the force used to stomping will lead to a response from the top physique to fight the route of the pressure springing up from the actions taken by foot. Judging from the appearance to the four subjects, it appears that the function of the arm between the problem with each different incredibly distinct in spite of having almost the equal performance principles. On the engineering front kick motion, the movement of the arm significantly decide the stage of have an effect on on the target and affected the amount of force used to kick. Position both hands are inclined closer to the bottom of the situation 4 indicates that the force used to kick to be larger so as to reduce the velocity at the time forward movement. In addition the role of the subject's arm four will have a tendency to inhibit the motion of the foot strike towards the pinnacle so that the have an impact on on the goal is unable to be high due to the fact of the contradictory movement between the arm and leg attack.

In the Pencak Silat Tanding Category, the function of the fulcrum is very influential at the time side kick technique therefore serves as a pivot in each and every motion of the body segment. The position of the subject tends to pivot foot facing the facet (left outside) except subject 3 is in the direction of the rear. It gives the feel that the foot pivot in the path of the pressure tends to be finished on foot attacked. As a result will make the concern less maintained the level of balance in the event of influence and follow via action becomes challenging to control.

5.3. The Phase of Follow-through

Results of the information recorded on the follow-through stage indicates variations that fluctuate from each subject of study. Stage follow through decisive implementation of the next motion. This learn about discusses the next shot that is used to lift out attacks. Therefore, at this stage of the follow-through of combatants ought to

be able to exhibit that efficient motion so it is no longer difficult to make a move that would do next. The results showed that almost all of the concern have no longer been able to display the effectivity of action that both at the stage of observe through.

Each implementation method movement a collection of moves that have to be carried out concurrently from the initial attitude to follow through. Therefore, the action error made on one stage will end result in an error of movement at a later stage. To that end, primarily based on the evaluation at this stage of the follow-through can be concluded that the motion of the front kick approach performed with the aid of Pesilat of PPLM DIY is but efficient so that less high quality when used in a game.

6. Conclusion and Suggestion

Based tiers are carried out from the establishing to the data analysis, the conclusions of this study can be introduced as follows: (1) Performance kick technique towards Pesilat of PPLM DIY at this stage of the mindset of publish suggests that big perspective knee flexion rear legs tend to be smaller than the angle knee flexion in the limbs that are in front (except the concern 1) so it is extra efficient for the implementation of subsequent motion; and (2) Performance kick approach forward Pesilat PPLM DIY from just before take-off till the have an effect on is nonetheless not efficient, such as: the position of the head nonetheless bent, the function of the head and fulcrum not upright, and the function of the fulcrum inclined in the route style of the legs strike; and (3) Performance front kick at this stage of the follow-through is inefficient.

Ultimately, as the suggestions that can be delivered associated with lookup outcomes are as follows: (1) It is critical to socialize the use of equipment that can be used for motion analysis as Dartfish Prosuite, Kinovea or others; (2) For in addition research, the use of cameras use that has the capability recording movement in faster motion; (3) When the usage of extra than one camera, preferably the use of a camera that has the identical specifications. Samples reproduced so the outcomes are clear and detailed; and (4) must be carried out evaluation of all motion methods used in Pencak Silat Tanding Category

References

- [1] Agung Nugroho. 2001. Diktat Pedoman Latihan Pencak Silat. Yogyakarta: FIK-UNY.
- [2] 2005. Laporan Penelitian Identifikasi Skor Prestasi Teknik Pencak Silat Pada Kategori Tanding. Yogyakarta: FIK UNY.
- [3] Bartlett, Roger. 2007. Introduction to Sports Biomechanics: Analysing Human Movement Patterns. 2nd Edition. New York: Taylor & Francis.
- [4] Bompa, Tudor O and Haff, G Gregory. 2009. Periodization: Theory and Methodology of Training. 5th Edition. Champaign, IL: Human Kinetics. P.O. Box 5076.
- [5] Borg, Walter R. dan Gall, M.D. 2003. Educational Research: An Introduction. 3rd Edition. New York: Pearson Education, Inc.
- [6] Baumgartner, T.A., Strong, C.H., & Hensley, L.A. 2000. Conducting and Reading Research In Health And Human Performance (3 rd ed.) Boston: Mc. Graw-Hill.
- [7] Cashmore, Ellis. 2008. Sport and Exercise Psychology. The 2nd Edition. New York: Routledge Taylor and Francis Group.
- [8] Crew, Henry. 2008. The Principles of Mechanics. BiblioBazaar, LLC. p. 43. ISBN 0-559-36871-2.
- [9] Djemari Mardapi. 2008. Teknik Penyusunan Instrumen Tes dan Nontes. Yogyakarta: Mitra Cendekia Press.
- [10] Hamill, Joseph dan Kuntzen, Kathleen M. 2009. Biomechanical Basis of Human Movement. 3rd Edition. Lippincott: Williams and Wilkins
- [11] Hong, Youlian. 2000. Biomechanical Analysis of Taekwondo Kicking Technique Performance & Training Effects. Hong Kong Sports Development Board (SDB). No. 2. pg. 1-5.
- [12] Hughes, Mike dan Franks, Ian M. 2008. The Essentials of Performance Analysis. New York: Routledge Taylor and Francis Group.
- [13] Johansyah Lubis. 2004. Pencak Silat Panduan Praktis. Jakarta: PT. Raja Grafindo Persada.
- [14] Kotot Slamet H. (2003). Teknik Dasar Pencak Silat Tanding. Jakarta: PT. Dian Rakyat.

Motion Analysis Of The Front Kick Technique Of Pencak Silat Athlete

- [15] McGinnis, Peter Merson. 2005. *Biomechanics of Sport and Exercise*. 2nd Edition. Champaign, IL: Human Kinetics.
- [16] Nordin, Margareta dan Frankel, Victor. 2012. *Basic Biomechanics of the Musculoskeletal System*. 4rd Edition. Philadelphia: Lippincott and Wilkins.
- [17] Persilat. 2012. *Peraturan Pertandingan Pencak Silat*. Jakarta: Persekutuan Pencak Silat Antar Bangsa.
- [18] Sukadiyanto, 2011. *Pengantar Teori dan Metodologi Melatih Fisik*. Bandung: Lubuk Agung.
- [19] Wilkinson, Carol; Pennington, Todd R dan Padfield, Glenna. 2000. Student Perceptions of Using Skills Software in Physical Education. *JOPHERD*. 71, 6 pg. 37.
- [20] Witte, Kerstin., Emmermacher, Peter., Langenbeck. Nico., and Perl, Juergen. 2012. Method To Visualize and Analyze Similarities Of Movements-Using The Example Of Karate Kicks. *Journal Kinesiology* 44 (2012) 2:155-165.
- [21] Wuest, Deborah A dan Bucher, Charles A. 2009. *Foundation of Physical Education, Exercise Science, and Sport*. 6th Edition. New York: McGraw-Hill Companies, Inc.
- [22] Zahran, Ahmed Saeed and Moneim ElSeoufy, Ahmed Abdel. 2010. Biomechanics' Determinants of The Trunk Front Semi-Circular Kick (Dollyo Chagi) in Tae-Kwon-Do. *World Journal of Sport Sciences* 3 (S): 921-929.