Jurnal SPORTIF: Jurnal Penelitian Pembelajaran
Vol. 6 No. 1, April 2020, pp. 145-156
https://doi.org/10.29407/js_unpgri.v6i1.14001

Analisis *sport* aerobik and anaerobik berbasis biomekanika

Biomechanical based aerobic and anaerobic exercises analysis

Topo Suhartoyo[1], Mohammad Nanang Himawan Kusuma[2], Didik Rilastiyo Budi[3], & Arfin Deri Listiandi[4]

[1,2,3,4]Faculty of Health Sciences, Universitas Jenderal Soedirman, Jl. Profesor DR. HR Boenyamin No.708, Dukuhbandong, Grendeng, North Purwokerto District, Banyumas Regency, Central Java Province, 53122, Indonesia.

Received: 29 November 2019; Revised: 2 January 2020; Accepted: 24 March 2020

Abstrak

Biomekanika merupakan kajian ilmu yang fokus pada penerapan dan analisis meliputi hukum, bentuk dan jenis gerakan. Nomor lari 100 meter dan 1.600 meter mempunyai karakteristik gerak yang berbeda, hal ini dapat dilihat dari sudut lengan, tungkai dan togok. Penelitian ini bertujuan menganalisa gerak *sport aerobic* dan *anaerobic* berdasarkan analisis biomekanika. Metodologi Penelitian ini menggunakan jenis penelitian deskriptif kuantitatif. Teknik sampling menggunakan *purposive sampling*. Populasi penelitian mahasiswa PJKR UNSOED berjumlah 60 mahasiswa. Teknik analisis data menggunakan software *kinovea.* Hasil penelitian menunjukkan bahwa sudut tubuh untuk nomor *lari* 1.600 meter menunjukkan besar sudut tubuh sebesar 138°, sudut tungkai sebesar 132° dan ayunan lengan sebesar 67°. Sedangkan nomor lari 100 meter menunjukkan besar sudut tubuh sebesar 117°, sudut tungkai sebesar 137° dan ayunan lengan sebesar 65°. Kesimpulan dari penelitian ini adalah deskripsi besar sudut tubuh nomor lari 100 meter lebih condong ke depan sebesar 20°dibandingkan nomor lari 1.600 meter, sudut tungkai nomor lari 100 meter lebih kecil sebesar 5°, ayunan lengan nomor lari 100 meter lebih kecil sebesar 2° dan software *kinovea* dapat digunakan dan mampu memberikan data yang jelas berdasarkan analisis biomekanik.

Kata kunci: aerobik, anaerobik, atletik, biomekanika, *kinovea*.

Abstract

Biomechanics is a study of science that focuses on the application and analysis of laws, forms and types of movements. 100-meter run and 1,600-meter run have different motion characteristics according to body, arms and leg angles. This study aims to analyze the motion of aerobic and anaerobic exercises based on biomechanical analysis. Research methodology uses quantitative descriptive research type. The sampling technique employs purposive sampling. The population is 60 Physical Education, Sport, Health and Recreation (PJKR) students of Jenderal Sudirman University (UNSOED). Data analysis technique applies kinovea software. The results show that 1600-meter run records the body angle of 138°, leg angle of 132° and arm swing angle of 67°. While 100-meter run shows the body angle of 117°, leg angle of 137° and arm swing angle of 65°. Hence, this study concludes that the description of 100-meter run body angle is leaning 20° forward compared to 1,600-meter run, the leg angle of 100 meter run is smaller 5° compared to 1,600-meter run, and 100 meter run swing arm is smaller 2 ° compared to 1,600-meter run. Futhermore, kinovea software

Correspondence author: Topo Suhartoyo, Universitas Jenderal Soedirman, Indonesia.
Email: *topo_suhartoyo@yahoo.co.id*

has capability to provide clear data based on biomechanical analysis.

Keywords: aerobic, anaerobic, athletic, biomechanics, kinovea.

INTRODUCTION

The scientific study of biomechanical analysis on short and long distance running should be improved and involves sophisticated application to aid its thorough analysis. In addition, those races have different characteristics. However, some still perceive that all races are similar by looking at the swing of the arm, leg angle and leaning of the body. Biomechanics is a scientific study that is able to bridge problems related to body movements clearly. Kusuma (2019) states Biomechanical exercise is interpreted as a science that applies the principles of mechanics to the structure of human body while doing exercise.

One of methods to aid athletes to form and automatize movements on race, in line with motion principles, is employing biomechanical analysis while performing specific movement. Biomechanical exercise is a science that implements mechanical principles on humans' physical structure while exercising. Biomechanics study aims to identify talents, train technical skills, evaluate technical skills, and provide treatments for recovery. The result of the analysis is advantageous specifically to coaches, teachers, physiotherapists, and sport practitioners.

The goals of the research are to analyze, describe, and improve research related to biomechanical analysis of 100-meter run and 1,600-meter run. The analysis is based on data of videos and photos which capture the angles of body while running. Thus, the data is analyzed with kinovea software which focuses on the analysis of arms, leg, and body angles while running. Those three components establish the ideal angle to be performed either in 100-meter run or in 1,600-meter run.

Humans' physical capability divides into anaerobic and aerobic capability. The high anaerobic capability enables ones to perform simple to hard movement repeatedly. Aerobic capability postpones the level of fatigue and helps to recover thoroughly. Fundamentally, physical training is an effort to raise the limit of ones' maximum capability.

https://doi.org/10.29407/js_unpgri.v6i1.14001
6 (1) 2020 | 145-156

Palar, Wongkar, & Ticoalu (2015) states that aerobic exercise is a training which requires oxygen to form the energy continuously, with the involvement of big muscles particularly leg muscles, on 60%-90% training intensity from *Maximal Heart Rate* (MHR) and 50%-85 % of the use of oxygen for 20-50 minutes.

Syahputra (2017) states aerobic and anaerobic physical activities have impacts on thrombosis volume enhancement, but the enhancement affected by either aerobic or anaerobic activities has no differences. Harahap & Pahutar (2017) state aerobic and anaerobic physical activities have impacts on leucosis volume enhancement, but the enhancement affected by either aerobic or anaerobic activities has no differences. Sukmaningtyas (2002) states aerobic activity has no impact on sistolic pressure and reactical speed. Meanwhile, anaerobic activity has no impact on sistolic and diastolic pressure but affects reactical speed. Moreover, aerobic and anaerobic physical activities also affect blood pressure, pulse, and reactical speed.

1,600-meter run reflects the characteristics of aerobic exercise which is in line with this research basic theory and variables. Besides, the usage of kinovea on 1,600-meter run research is rare. Hopefully, the analysis result empowers 1,600-meter run theoretical foundation and is able to inspire future research on movements and energy system. Ulum (2014) suggests that short interval exercise enhances the anaerobic endurance. Nasrulloh (2009) mentions that aerobic exercise combined with specific technical skills improve cardio-respiratory functions.

Muscle constraction is obtained through metabolism process. Within the body, there are two kinds of metabolism process, namely anaerobic and aerobic. Anaerobic activity without using oxygen, produces power that is directly used to produce muscle contraction. High-intensity anaerobic activity is not applicable for long duration. This is one of the bases for the selection of variables in the study; 100-meter run is theoretically included in the type of anarobic exercise.

https://doi.org/10.29407/js_unpgri.v6i1.14001
6 (1) 2020 | 145-156

Biomechanics is a scientific study that studies the internal and external forces acting on the human body as well as its impact (Abdurrahmat, 2011). This study requires the flow and principles of body movements in the position of preparation, implementation and the end. The quality of one's body movements will be observed in detail, then analyzed clearly (body position) by involving equipment in the form of a camera so that it displays detailed data (Bartlett & Roger, 2007).

Kurniawan (2008) theorizes biomechanics can be grouped into 2, namely Kinematics and Kinetic. Kinematics is a science that describes all kinds of movements and does not concern the forces that cause motion. Meanwhile, Kinetic is a branch of mechanics that takes into account the forces that produce or change motion. Thus, this well-defined distinction is established in order to avoid mistake usage in biomechanics terms.

Kinematics consists of 2 divisions, linear and angular. Linear is the transformation of body position of a movement. Generally, it is a movement of speed and acceleration, for example 100-meter run and relay race in athletic sports. These 2 movements reflect biomechanical principles from the side of the body to the speed. Meanwhile, angular is a rotation of the body that explains the process of moving body segments to other body segments. Long-distance run or 1,6 - 2,4-kilometers run is the example. Such sport can be observed on body segment position, in terms of the slope of the body to the swinging of the feet. Perdana (2009) explains that Kinetic is divided into 2 similar divisions; linear and angular, but different on the implementation. Force is the basic principle of kinetic, without it, the purpose of the movement is unclear.

METHODS

This is quantitative research which was conducted from May until August 2018 at Soesilo Soedirman sport center, Jenderal Soedirman University (UNSOED). Samples and population in this research are 60 Physical Education, Sport, Health and Recreation (PJKR) department students of 2017 class, Jenderal Soedirman University (UNSOED). Sugiyono (2016) mentions that population is generalization area consists

https://doi.org/10.29407/js_unpgri.v6i1.14001
6 (1) 2020 | 145-156

of subject or object having definite quantity and characteristics determined by researcher(s) to be observed and concluded. Sampling technique employs purposive sampling in order to enable researchers selecting the samples based on research goals, limitation of time, and supporting research equipments. Furthermore, data analysis employs Kinovea software. This software aids to find out the amount of the angle produced by body movement while running. The running is recorded into video and uploaded into the software in which the produced angles are analyzed.

The preliminary data retrieval process was conducted by performing running test to divide students into aerobic and anaerobic groups. The first test was 100-meter run in 12 seconds. Afterward, the next test was 1,600-meter run in 10,30 minutes. Test was held at 3.30 p.m. until 5.10 p.m. at Soesila Soedarman sport center, Purwokerto.

The next step was the recap of each race as the foundation to determine the group. Specifically, 100-meter run was done twice to gain the best time record. 1,600-time run test was conducted just once by highlighting time and physique of respondents.

The respondents performed 100-meter run first and continued with 1,600-meter run. After test conducted, the retrieved data was recapitulated as the means to determine groups division based on the obtained time record. The first test showed as many 30 students were able to succeed run within the limit time of 12.00 seconds. Unfortunately, the other 30 students failed to complete under the given time, so they are included into 1,600-meter run group. The test was conducted in a day.

The first elements to be analyzed are leg angle, body position, and arms swing. Those three are 3 principles in forming run movement. Those have function to minimize air pressure or wind which slow down the movement.

RESULTS

Biomechanical analysis of exercise techniques can be classified into 2; qualitative and quantitative analysis (Kusuma, 2019). Qualitative analysis, generally, describes observation, evaluation, and instruction.

https://doi.org/10.29407/js_unpgri.v6i1.14001
6 (1) 2020 | 145-156

Meanwhile, quantitative analysis highlights measurement (time, kinematic, energy, effort, and power.) The final result of biomechanical analysis is to describe the characteristics of the observed and analyzed sport performance.

The division of groups, according to the initial series of test of 100-meter run for twice within 12,00 seconds limit, produce 2 groups. First group is aerobic group within 12,00 second limit consists of 30 samples. Second group, anaerobic group consists of those who spent more than 12,00 seconds consists of 30 samples.

Figure 1. The result of Kinovea analysis for 100-Meter run

The usage of Kinovea analysis on figure 1 results the angle of leg, body, and arm on 100-meter run. This is in line with this research goal to be able to analyze the angle of movement while running on 100-meter run. The result is recapped on the following table;

Table 1. Biomechanical analysis result of 100-meter run

Position	angle
Legs	137°
Body	117°
Arms	65°

According to the table 1, a leg angle of 137° will result in thrust or explosion when running or reaching maximum acceleration in 100-meter run. Leaning body of 117° shows big inclination that will affect the wind resistance caused by running speed. While arm angle of 65° serves to

https://doi.org/10.29407/js_unpgri.v6i1.14001
6 (1) 2020 | 145-156

ISSN : 2477-3379 (Online)
ISSN : 2548-7833 (Print)

maintain body balance while running from start to finish. This is supported by the results of research that explains that there is a relation between ankle coordination, leg muscle explosive power and self-confidence along with the results of a 100-meter run (Anggara, 2018).

Whereas, the results of 1,600-meter run analysis using kinovea software as follows:

Figure 2. Kinovea Analysis Results of 1,600-meter Run

The results of the analysis in figure 2 ilustrate 1,600-meter run conducted by 30 samples according to the group, the obtained data can be recapitulated in table 2, as follows:

Table 2. Recap of Biomechanical Analysis on 1,600-meter run

Position	Angle
leg	132°
Body	138°
Arms	67°

From the results of the analysis, the leg angle of 132° makes more stable explosive power so that the rhythm of the legs can be maintained. Body angle of 138° aims to maintain and stabilize the energy system or endurance while running. This is related to the purpose of running the test, one of which is to find out VO2Maks. 67° arm position is intended to maintain balance while running. This is in line with a research that states that the energy system used in the 1,500-meter run is 50% anaerobic and 50% aerobic (Sumintarsih, 2001).

https://doi.org/10.29407/js_unpgri.v6i1.14001
6 (1) 2020 | 145-156

DISCUSSION

Kinovea software enables this research to analyze the angles of physical components that affect the quality and quantity of 100- meter and 1,600-meter run. First, the discussion focuses on the results of 100-meter run analysis by taking into account the size of the angle of the arm, body and legs.

In line with the results of the study, running conducted by research subjects obeys the running technique such as the body leaning forward, swinging the arms form an angle of ± 90º opposite to the leg movements (Faizah & Herdyanto, 2019). Furthermore, a similar study shows that 100-meter run with a highest-frequency stride length of 2.77 m with an angle of 125º is achieved at a distance of 80 meters, and an average stride length of 2.65 meters produces a total step frequency of 41 steps (Nurhayati 2019).

Other research results state that runners can accelerate at a distance of 0-50 meters with an average acceleration value of 1.23 m / s, and at a distance of 80-90 meters with an average acceleration value of 1.23 m / s (Rahadian, 2019). 100-meter run is analyzed and then proclaimed in several steps as follows; the acceleration step (0-30 meters), maximum acceleration (30-80 meters) and 80-100 meters (accelerated).

Several factors that correlate with the ability in 100-meter run are legs, arms and leaning of the body. The results of previous studies show that body structure (anthropometrics), height, weight and abdominal fat are not closely related to 100-meter run results, because the tall athletes have long strides and do not have a good acceleration which is not beneficial for them. Weight and belly fat are not closely related to 100-meter run result (Wira, 2014).

100-meter run Researches are dominated by anthropometrics factors. Similar research results state that there is a very strong and significant relationship between height, weight and running speed of 100-meter run (Parwata, 2017). The more dominant characteristic of 100-meter

https://doi.org/10.29407/js_unpgri.v6i1.14001
6 (1) 2020 | 145-156

run is the fast movement so that the body's efficiency and effectiveness are needed. So, physical factors such as body weight and height are needed to support fast running.

Furthermore, research strengthens theories related to Body Mass Index (BMI) which states that the higher the body mass index, the greater the strength of a hand grip and the longer the required travel time (Hutomo & Budiharjo, 2015). 100-meter run is a high intensity and fast type of physical activity. This is in accordance with a research that discusses the energy system which states that moderate and high levels of physical activity in increasing physical activity affects energy and fat intake (Mulyadi, 2013).

In addition, there are diverse differences influenced by several factors in anthropometry and energy systems. This is supported by research recommendations which state that in 100-meter run, 4 physical condition components need to be considered including anthropometrics, leg muscle strength, reaction speed, and flexibility (Tisna, 2017). In addition, the characteristics of exercises performed by athletes can provide habits or automation of performed running. This analysis is a study that can be applied to see the ideal angle for each athlete so that the movement becomes more effective and efficient.

In the end, this study is able to answer the objectives of 100-meter run analysis with a 117º body leaning, 65º arm swing and 137º leg angle. This analysis is able to describe the angle of 100-meter run. In this type of run, a leaning of the body is needed to minimize the wind pressure experienced by runner at maximum speed. Arms swing is needed to improve and maintain balance while the legs are needed as a fulcrum when running so that movement is more effective and efficient. This means that the longer range of leg will result in faster and greater power to produce leg explosive power.

Furthermore, an analysis of 1,600-meter run is described into the result of the angle of the legs, body and arms. In addition, this race aims to determine the quality of VO2Maks sample. This is reinforced by the results

https://doi.org/10.29407/js_unpgri.v6i1.14001
6 (1) 2020 | 145-156

of a study that stated that 800-meter run and 1,500-meter run affect the increasing of VO2Maks, and 1,500-meter run increases more VO2Maks than 800-meter run (Astrawan, Parwata, & Budiawan, 2014).

In 1,600-meter run, the data results mentions body leaning of 138º, arm swing of 67º, and leg angle of 132º. Such data proves that the leaning of the body is not as small as 100-meter run due to not too big wind resistance so runners more concentrate on stability and increase Vo2Maks capacity. This is reinforced by Giriwijoyo's view (2017) that increasing anaerobic capacity increases anaerobic endurance and runners will be able to perform more maximal explosive movements while running. The swing arm angle serves to maintain the tempo while running. The leg angle maintain the tempo of this running motion.

CONCLUSION

Based on the results of running test and the use of kinovea software, the biomechanics analysis of 100-meter run and 1,600-meter run are elaborated. Those have 20° differences of body position. 2° difference of arm swing in those types of run is not too much because arm swing serves to maintain body balance. The last, the difference of leg angle is 5°. This study shows that there are differences in the angles and techniques performed by each category.

ACKNOWLEDGEMENT

The researchers would like to thank All lecturers in Physical Education, Sport, Health and Recreation (PJKR) Department, Sudirman University (UNSOED), athletic methodology team teaching in Physical Education, Sport, Health and Recreation (PJKR) Department, Sudirman University (UNSOED), and 2017 class students who are willing to become research subjects.

REFERENCES

Abdurrahmat, A. S. (2011). Analisis Biomekanik Pukulan Forehand pada Olahraga Tenis. *Jurnal Health & Sport*, 2(2), 127-198.

https://doi.org/10.29407/js_unpgri.v6i1.14001
6 (1) 2020 | 145-156

Anggara, T. (2018). Hubungan Koordinasi Mata kaki, Daya Ledak Otot Tungkai dan Percaya Diri dengan Hasil Lari Sprint 100 Meter pada Atlet PPLP Bangka Belitung . *Jurnal Ilmu Keolahragaan*, 135 - 146.

Astrawan, I. P., Parwata, I. G. L. A., Budiawan, M., & Ked, S. (2014). Pengaruh Pelatihan Lari 800 M Dan Lari 1500 M Terhadap Volume Oksigen Maksimal (VO2MAKS). *Jurnal Ilmu Keolahragaan Undiksha*, *2*(1).

Bartlett & Roger. (2007). *Introduction to Sports Biomechanics Second Editon: Analysing Human Movement Pattern*. Paris: Taylor & Francis e-Library.

Faizah, A., & Herdyanto, Y. (2019). Analisis Gerak Akselerasi Sprint 100 Meter (Studi pada Atlet Lari Sprint 100 Meter Putra Pelatnas B, Ditinjau dari Aspek Biomekanika). *Jurnal Prestasi Olahraga*, *1*(1).

Giriwijoyo, S. (2017). *Fisiologi Kerja Dan Olahraga.* Jakarta: PT. Raja Grafindo.

Harahap, N. S., & Pahutar, U. P. (2017). Pengaruh Aktifitas Fisik Aerobik dan Anaerobik Terhadap Jumlah Leukosit Pada Mahasiswa Ilmu Keolahragaan Universitas Negeri Medan. *Sains Olahraga: Jurnal Ilmiah Ilmu Keolahragaan*, *1*(2), 96-104.

Hutomo, G. A., & Budiharjo, S. (2015). *Korelasi Antara Indeks Massa Tubuh dengan Kekuatan Genggam Tangan dan Waktu Tempuh Lari 100 Meter Pada Remaja Usia 15-17 Tahun Sekolah Menengah Atas Taruna Nusantara, Magelang, Jawa Tengah* (Doctoral dissertation, Universitas Gadjah Mada).

Kridasuwarso, B. (2016). Analisis Biomekanika Olahraga Dan Belajar Motorik Pada Start Jongkok Lari Gawang. In *Prosiding Seminar dan Lokakarya Fakultas Ilmu Keolahragaan Universitas Negeri Jakarta, 1(1), 17-21.*

Kurniawan, F. (2008). Analisis Secara Biomekanika Teknik Gerak Serang dalam Anggar. *Jurnal Universitas Negeri Yogyakarta*.

Kusuma, M. N. (2019). *Biomekanika Olahraga.* Purwokerto: Unsoed Press.

Mulyadi, C. K. (2013). Hubungan Antropometri, Aktivitas Fisik, dan Pengetahuan Gizi dengan Asupan Energi dan Komposisi Makronutrien pada Remaja. *e-Journal Kedokteran Indonesia*, 90-99.

Nasrulloh, A. (2009). Pengaruh Latihan Aerobik Kombinasi Dengan Teknik Terhadap Kemampuan Kardiorespirasi Efek Tekanan Udara Terhadap Fisiologi Tubuh Atlet. *MEDIKORA*, (1).

Nurhayati, C. D. L. (2019). Analisis Gerak Nomor Lari Sprint 100 Meter Putra Cabang Olahraga Atletik (Studi Kasus Pada Usain Bolt Di Kejuaraan International Association of Athletics Federation Berlin Tahun 2009). *Jurnal Kesehatan Olahraga*, *7*(1).

Palar, C. M., Wongkar, D., & Ticoalu, S. H. (2015). Manfaat latihan olahraga aerobik terhadap kebugaran fisik manusia. *eBiomedik*, *3*(1).

Parwata, I. M. Y. (2017). Hubungan Tinggi Badan dan Berat Badan terhadap Kecepatan Lari 100 Meter Mahasiswa Putra Fpok IKIP PGRI Bali. *Jurnal Pendidikan Kesehatan Rekreasi*, *3*(2), 19-27.

Perdana, A. (2009). Aplikasi Analisis Biomekanik Untuk Mengembangkan Kemampuan Belari Atlet Lari. *Skripsi Program Studi Teknik Informatika*.

Rahadian, A. (2019). Aplikasi Analisis Biomekanika (Kinovea Software) Untuk Mengembangkan Kemampuan Lari Jarak Pendek (100 M) Mahasiswa PJKR Unsur. *Journal of SPORT*, *3*(1), 1-8.

Sari, R. M. (2015). Aplikasi Biomekanika Nomor Lari 100 Meter Cabang Olahraga Atletik. *Jurnal Pengabdian Kepada Masyarakat*, *21*(81).

Sugiyono. (2016). *Memahami Penelitian Kualitatif*. Bandung: Alfabeta.

Sukmaningtyas, H. (2002). Pengaruh Latihan Aerobik dan Anaerobik Terhadap Sistem Kardiovaskuler dan Kecepatan Reaksi. *eprints.undip*.

Sumintarsih, S., & Tri, S. (2001). Sistem energi dan metode latihan lari 1500 meter. *Majalah Ilmiah Olahraga Fakultas Ilmu Keolahragaan Universitas Negeri Yogyakarta*, *7*, 1-12.

Syahputra, T. H. (2017). *Pengaruh Aktifitas Fisik Aerobik dan Anaerobik Terhadap Jumlah Trombosit Pada Mahasiswa Ilmu Keolahragaan 2015 Universitas Negeri Medan* (Doctoral dissertation, UNIMED).

Tisna, G. D. (2018). Profil Antropometrik, Kekuatan Otot Tungkai, Kecepatan Reaksi dan Fleksibilitas pada Atlet Lari 100 Meter. *JURNAL PENJAKORA*, *4*(2), 46-57.

Ulum, M. F. (2014). Pengaruh Latihan IntervaL Pendek Terhadap Peningkatan Daya Tahan Anaerobik. *Jurnal Kesehatan Olahraga, 2(1)*.

Wira, U. (2014). *Studi Analisis Struktur Tubuh (Antropometrik) Terhadap Lari Sprint 100m Pelari Jarak Pendek PPLP dan PPLM Jawa Barat* (Doctoral dissertation, Universitas Pendidikan Indonesia).

Zuhdi, M. S. (2013). Analisis Gerak Lari Sprint 60 Meter Secara Biomekanika. *Jurnak Kesehatan Olahraga, 1(2)*.

https://doi.org/10.29407/js_unpgri.v6i1.14001
6 (1) 2020 | 145-156