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Prediction of The Optimal Performance of Running Athletes

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Abstract

This research is a scientific study between disciplines, especially mathematics and sports. The problem in this research is how to model the optimal time prediction for the performance of athletic athletes, especially running, based on data from national and international championship results. The aim of this research is to find a prediction model for optimal performance times for running athletes based on national and international time record data. The solving method in this research uses mathematical methods, namely the least squares method and forecasting with the help of Excel and SPSS programs. Through this research, it is hoped that it will become input for scientific information, especially for athletics (running) so that it can predict athlete performance based on optimal time prediction models so that training targets are well directed. Athletes can provide positive motivation from these predictions. Practically, for coaches, teachers and sports coaches, athletics can be a basis for creating training programs to create better performance. The optimal time prediction model produced in this research can provide an overview of running achievements both nationally and internationally. Apart from that, it can also be used to compare national and international achievements so that it can be used as evaluation material. The optimal time prediction model for running athletes' performance for short distances of 100m and 200m was obtained with a model that was significant at the 0.05 level of significance.
Keywords: optimal time prediction, least squares, forecasting, running.

Abstrak

Penelitian ini merupakan studi ilmiah antardisiplin, terutama matematika dan olahraga. Permasalahan dalam penelitian ini adalah bagaimana memodelkan prediksi waktu optimal untuk performa atlet-atlet atletik, khususnya lari, berdasarkan data hasil kejuaraan nasional dan internasional. Tujuan dari penelitian ini adalah untuk menemukan model prediksi waktu optimal untuk atlet lari berdasarkan data rekam waktu nasional dan internasional. Metode penyelesaian dalam penelitian ini menggunakan metode matematika, yaitu metode kuadrat terkecil dan peramalan dengan bantuan program Excel dan SPSS. Melalui penelitian ini, diharapkan dapat menjadi masukan untuk informasi ilmiah, khususnya untuk atletik (lari), sehingga dapat memprediksi performa atlet berdasarkan model prediksi waktu optimal sehingga target latihan dapat terarah dengan baik. Atlet dapat mendapatkan motivasi positif dari prediksi ini. Secara praktis, bagi pelatih, guru, dan pelatih olahraga, atletik dapat menjadi dasar untuk membuat program latihan guna menciptakan performa yang lebih baik. Model prediksi waktu optimal yang dihasilkan dalam penelitian ini dapat memberikan gambaran prestasi lari baik di tingkat nasional maupun internasional. Selain itu, dapat digunakan untuk membandingkan prestasi nasional dan internasional sehingga dapat digunakan sebagai bahan evaluasi. Model prediksi waktu optimal untuk performa atlet lari jarak pendek 100m dan 200m diperoleh dengan model yang signifikan pada tingkat signifikansi 0,05.
Kata Kunci: prediksi waktu optimal, kuadrat terkecil, peramalan, lari.

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INTRODUCTION

Several sports competitions rely on speed ability to determine best performance. These sports include athletics and swimming. In both sports, whoever is quickest is the champion. Talking about speed, it includes distance and time. Since the start of running competitions both nationally and internationally in various events, a lot of time data has been recorded. From race to race, from year to year until now the time records for each number are certainly getting better, meaning that many

records have been broken. However, this time data is still rarely used as reference material for improving better performance in the future. In fact, through certain mathematical methods, in this case the forecasting method, if we have some known time data, we can obtain a prediction model for the future so that it can be used as a reference in improving better performance.

Mathematical models for predicting the optimal time achieved in running sports based on time records achieved in national or international championships need to be studied. This is due to the tight competition for achievements in running sports, especially in short distance running events, namely the 100 m, 200m and 400m races. Apart from that, the need for coaches to improve athlete performance based on achievements that have been achieved at both national and international levels is very important to determine optimal training targets. According to Santoso, "training for performance sports is essentially improving the functional abilities of the body according to the demands of maximum performance in the sport, both in terms of basic abilities and technical skills.

Initial data, reference data and athlete progress data must always be recorded to be able to predict achievement." (Keller, 1973) mathematical model predicts optimal running times based on World Record results through simple differential equations in terms of physiological constants. (Mureika, 1997) (Mureika, 1998) refined Keller's model with a simple centrifugal force function acting on the runner around a curve based on World Records for 200m outdoor and 100m indoor. It is a case study for the 1996 Atlanta Olympics 100m World Record holder, Donovan Bailey of Canada.

Running is a simple sport, one of the events contested in athletics, both at regional, national and international levels. This athletic sport consists of several events, namely brisk walking, running, jumping and throwing. As explained above, running consists of short distance running (Sprint), middle distance running, long distance running and marathon. Mohammad Zohri (National Athlete, 3rd Place in the 100 meter dash at the Olympics, Golden Grand Prix Osaka 2019, Japan) performs the type of running technique he has mastered with full strength and speed along a predetermined track line from start to finish in order to achieve victory based on record shortest time. Short distance runners are called sprinters. Zohri specializes in running 100 meters, although there are 200 meters and 400 meters as alternative routes for short distance running.

(Bahagia, 2005) States that running is included in the flying phase, which is a body movement where both legs are floating in the air (both soles of the feet are off the ground), which is different from walking where the feet are always in contact with the earth or ground. Mochamad Djuminar explained that a runner will make an accelerated step frequency, so that at one time the body tends to float when he runs. This means that when the two stiffs float there is at least a set of stiffs supporting the ground. [5] Wikipedia defines running as a body movement (gait) where at one time there is a flying phase, all feet do not touch the ground. So, in contrast to walking where one leg must remain as support and in contact with the ground, whereas running is a body movement where both legs are present when they can float in the air or are not in contact with the ground. In the field of sports, there

are many things that we can appreciate in mathematical models.

Running is a sport that is contested in both official and unofficial championships. The running competition numbers consist of short distance running: 100m to 400m running which is carried out by maximizing all techniques starting from starting speed, sprinting and technique for entering the finish line, thus determining whether the time taken is good or bad. Middle distance running: 800 m to 1500 m. Long distance running: 3000m to 42,195 km because the distance is quite far, both use a standing start, requires very high skills, because it consists of exerting or utilizing maximum energy in a relatively short time (Agung, 2013). Many championships have been held in this swimming sport, both national and international, so there is also a lot of time record data. Through the least squares method and forecasting methods, the time data can be processed into a trendline equation. This trendline equation can be used as a time prediction model to determine future achievement times.

Seeing such symptoms and facts, researchers feel it is necessary to conduct research on optimal time prediction models for the performance of athletes in athletics, especially running, based on performance data that has been achieved. This research refers to the research umbrella program of the Department of Sports Coaching education, namely the development of sports achievements. This is a development of training and learning in athletic sports subjects. Apart from that, this research shows that the field of sports, especially running, can be studied from other disciplines, in this case mathematics, so this research is a sports mathematics topic. Thus, this research is an effort to improve the quality of training and learning and provide insight into the study of sports science in terms of mathematics.

METHOD

The research method used in this research is a descriptive method with case studies. Where it was tried for several cases, in this case the results of world and national level championships so that from these cases models were obtained that were appropriate to the case.

The object of this research is the best time record in the 100m, 200m and 400m short distance running championships. The subject of this research is a mathematical model obtained through the least squares method and a forecasting method based on the best time data (object).

The research instrument used to obtain data was taking data from data sources through internet searches of national and international competition results to obtain short distance running records.

The instruments for analyzing data are mathematical methods, namely the least squares method and forecasting methods with the help of Microsoft Excel and SPSS programs to determine suitable mathematical equation models.

Research stages

1. Carrying out theoretical analysis regarding running and mathematical methods
2. Analysis of relevant previous research results
3. Recording the best times from short distance running competitions at both national and

international levels

4. Processing and analyzing data through mathematical methods to produce results optimal time prediction model for the performance of athletes in short distance running for competitions namely 100m, 200m, 400m for men and women using mathematical methods
5. Carry out model testing
6. Choose a mathematical model to best predict optimal times.

RESULTS AND DISUSSION

The research results that have been achieved have only obtained data on the performance of short distance running athletes from the 2023 Sea Games. Data on the performance of short distance running athletes for 100 meters and 200 meters obtained descriptive results as follows:

Table 1. Description of Athlete Performance running distances of 100 meters and 200 meters

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Sprint100	7	10.37	10.93	10.6157	.19518
Sprint200	8	20.74	21.44	21.1588	.25931
Valid N (listwise)	7				

The results of the normality test of performance data for athletes running short distances of 100 m and 200 m are as follows:

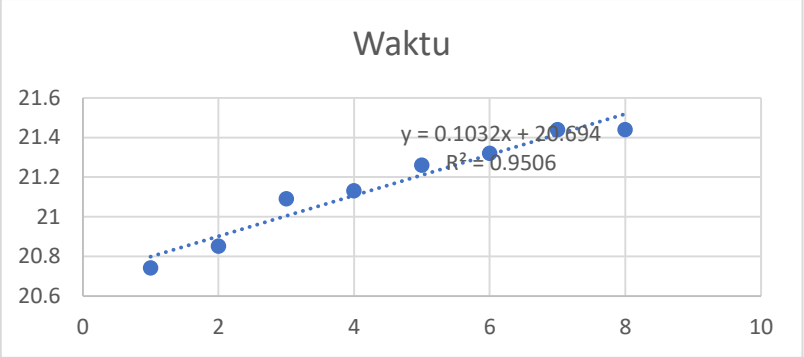
Table 2 Performance Normality Test for Athletes Running Distances of 100 meters and 200 meters

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Sprint100	.184	7	.200*	.961	7	.828
Sprint200	.169	7	.200*	.955	7	.773

The following is a graph of the results of an analysis of the performance of athletes running a distance of 200m

Gambar 1. Grafik Performance Results of 200m Running Athletes



Gambar 2. Graph Linearity graph, Regression equation and Correlation of 200m Running Athlete Performance

The results of the regression equation are obtained

y = 0,1032 x + 20,694

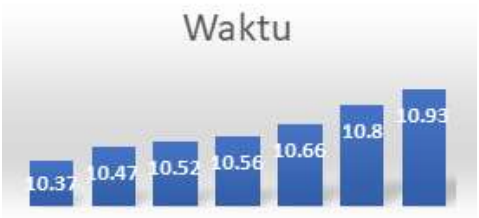
with a coefficient of determination of 0.95

Table 3. Significance Test Results of the Optimal Time Prediction Model for 200m Running Athletes

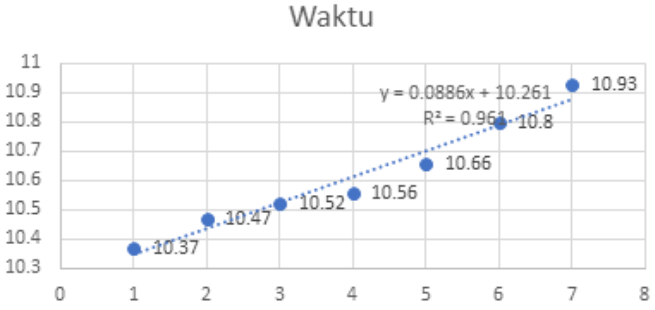
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	20.858	.169		123.181	.000
Rank200	.067	.034	.631	1.992	.093

The prediction model obtained has sig. = 0.00 < 0.05 then the significant model can be used as a prediction model for the optimal performance time of athletes running a distance of 200m

The following is a graph of the results of an analysis of the performance of athletes running a distance of 200m



Gambar 3. Graph Performance Results of 100m Running Athletes



Graph 4. Linearity graph, Regression equation and Correlation of 100m Running Athlete Performance

The results of the regression equation are obtained

y = 0,0886 x + 10,261 with a coefficient of determination of 0,961

Table 4. Significance Test Results of the Optimal Time Prediction Model for 100m Running Athletes

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	10.261	.036		287.550	.000
	Rank100	.089	.008	.980	11.100	.000

a. Dependent Variable: Sprint100

The prediction model obtained has sig. = 0.00 < 0.05 then the significant model can be used as a prediction model for the optimal performance time of athletes running a distance of 100

Discussion

Based on the analysis carried out above, the findings were that for the 200m, 100m norm, it shows that the higher the performance, the longer the time level. The forecasting method is a way of predicting or estimating quantitatively or qualitatively what will happen in the future, based on relevant data in the past. This forecasting method is used in objective forecasting. Meanwhile, the use of forecasting methods is to estimate systematically and pragmatically on the basis of relevant data in the past, thus forecasting is expected to provide greater objectivity (Clemen, 1989).

Least Square Method: The methods used for time series analysis are the Free Hand Method, the Semi Average Method, the Moving Average Method and the Least Squares Method. Square Method) (Deb et al., 2017). In this case, we will focus more specifically on discussing time series analysis using the least squares method which is divided into two cases, namely the case of even data and the case of odd data. In general, the linear line equation from time series analysis is:

Y = a + b X. (1)

Information :

Y is the variable whose trend is sought and

X is a time variable (year).

Meanwhile, to find the values of constant (a) and

parameter (b) are:

a = ΣY / N and b =(ΣYx)/ΣX2

Least Square Method (least square), this method is most often used to predict y, because the calculations are more precise. Formula for finding the trend line equation 0.

The results of the regression equation are obtained for number 100 m is:

y = 0.0886 x +10.261 (2)

with a coefficient of determination of 0.961

For the 200 meter number, the regression equation is:

y = 0.1032 x +20.694 (3)

with a coefficient of determination of 0.95

Both equation models are significant at the 0.05 significance level.

Furthermore, based on (Heazlewood, 2006), Prediction Versus Reality: The Use Of Mathematical Models To Predict Elite Performance In Swimming and Athletics at The Olympic Games, ©Journal of Sports Science and Medicine (2006) 5, 541-547, a research in (Hidayah, 2010) with the title Optimal Time Prediction Model in Swimming Sports Using the Trendline Equation. Tested cases for freestyle and style swimming men's and women's 50m, 100m, 200m back with samples according to age groups at national level and according to the number of world level matches from the first world level match to the latest time record.

The results of this research using the least squares method with the help of SPSS obtained 10 linear trendline time prediction models for the national level and 10 models at the international (world) level. Based on statistical testing and model trials, the time prediction models for the national level men's 50m backstroke and international women's 50m freestyle are the most suitable models.

In this research, the latest data will be tested for both national and international competitions for athletics, short distance running, 100m and 200m. The research results of Timothy Heazlewood, (Heazlewood, 2006) for freestyle swimming in the 50m, 100m, 200m, 400m, 800m, 1500m competitions, obtained a prediction model in the form of linear, nonlinear, cubic, inverse, sigmodial and exponential regression equations.

The results of research (Keller, 1973) modeled optimal running time predictions using simple differential equations. Research results (Woodside, 1991) state that the problem of maximizing running distance in a certain time is considered a problem in optimal control. The parameters involved are resistive force, maximum available driving force, energy supply level, initial energy level and fatigue constant.

(Mureika, 1998) refined Keller's model with a simple centrifugal force function acting on the runner around a curve based on World Records for 200m outdoor and 100m indoor. It is a case study for the 1996 Atlanta Olympics 100m World Record holder, Donovan Bailey of Canada. (Péronnet & Thibault, 1989) conducted research to develop an empirical model that relates human running performance to several characteristics of metabolic energy-generating processes using anaerobic metabolic capacity (J/kg); MAP, maximum aerobic power (W/kg); and E, decrease in peak aerobic power with the natural logarithm of race duration T, when T is greater than TMAP = 420 seconds.

The research results of (Gaudet, 2014) models for the forces applied in the block, drive and maintenance phases, as well as for the braking forces, are proposed and based on experimental observations. The applied force and aerodynamic drag along with the speed and position of the sprinter are calculated by the model as a function of time. The unknown model parameters are physically relevant and quantitatively comparable to experimentally measured quantities. New mathematical method, not based on matching curve, is proposed along with a model that requires two observable quantities, the time of the first step and the start of the maintenance phase, and four time

divisions. The model was validated by modeling several elite sprints from available split data, as well as measured splits for non-elite sprinters, distances over 100 m and 200 m. Péronnet and Thibault proposed a logarithmic model based on decreasing use of the maximal aerobic speed fraction (Vandewalle, 2017).

CONCLUSION

This study investigated the 100m and 200m running events, establishing a significant correlation between performance and time. Utilizing the Least Squares Method for forecasting, the research generated regression equations for both events with high coefficients of determination, affirming the models' reliability. Comparative analyses with Heazlewood's elite performance research and Hidayah's Optimal Time Prediction Model in Swimming Sports added contextual validation.

Exploring a range of mathematical models, including linear, nonlinear, cubic, inverse, sigmoidal, and exponential regression equations, the study aimed to predict running and swimming performances. Drawing on contributions from Keller, Woodside, Mureika, Péronnet, Thibault, and Gaudet, the research highlighted diverse mathematical approaches in sports science. From differential equations to empirical models rooted in metabolic processes and sprinting phases, the study meticulously examined the intricacies of predicting athletic performance.

This research makes a substantial contribution to athletics by presenting robust models for forecasting optimal running times. The implications extend to coaches, athletes, and sports enthusiasts, offering valuable insights for shaping training programs and deepening comprehension of the factors influencing athletic success.

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