Original Article

Prediction of 10 km running time by physical and training characteristics in recreational runners

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ABSTRACT

Running is a common exercise that many people perform as their leisure activity. With increasing numbers of recreational runners, understanding the associations between physical and training characteristics and running time would provide useful knowledge for improving running performance. Therefore, the objective of this study was to investigate whether physical and training characteristics correlated with running time in recreational runners. Sixty recreational runners participated in this study. They were requested to run 10 km on track and provide details of their physical and weekly training characteristics. Relationships between physical and training characteristics and running time were analysed by using Pearson's correlation coefficient (r) and the influence of the physical and training characteristics on the running time was tested by using multiple regression. Results showed that running time was significantly correlated with body mass index (BMI; r = 0.275), training day (r = -0.583), training distance (r = -0.605), training duration (r = -0.446), running experience (r = -0.275), and numbers of participation in mini-marathon race (r = -0.311). These variables could predict 57% of variances in the running time. Among all variables, the weekly training distance showed the greatest effect on running time. It can be concluded that physical and training characteristics contributed to the changes in running time. With long distance and more days of weekly training, recreational runners would achieve a shorter running time. Furthermore, increasing the years of experiences and numbers of running races would provide beneficial effect on running performance.

Keywords: Performance analysis, Exercise, Mini-marathon, Sports performance, Race time, Training distance, Sport health.

Cite this article as:
Suwankan, S., Suwankan, S., Theanthong, A., & Kemarat, S. (2024). Prediction of 10 km running time by physical and training characteristics in recreational runners. *Journal of Human Sport and Exercise, 19*(1), 193-201. https://doi.org/10.14198/jhse.2024.191.17

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Submitted for publication September 30, 2023.
Accepted for publication October 17, 2023.
Published January 01, 2024 *(in press* November 15, 2023).
JOURNAL OF HUMAN SPORT & EXERCISE ISSN 1988-5202.

doi:10.14198/jhse.2024.191.17

INTRODUCTION

Recreational running or jogging is one of the leisure activities that is popular among all ages and can be performed over several places. Nowadays, there is an increasing number of recreational runners trained regularly to promote an active and healthy lifestyle and improve health status (Shipway & Holloway, 2010). Furthermore, many recreational runners challenge themselves to compete in running races of varying distances from 5 km to marathon races. To achieve their goals, runners utilize various training approaches by varying training distance, day, and duration (Casado et al., 2022; Saunders et al., 2004). Despite practical differences, previous studies found that training helped improving health status and performance in recreational runners (Boullosa et al., 2020; Midgley et al., 2007).

Variations in training characteristics have been observed among runners with different skill levels, and race distances. The training volume and intensity was increased if runners had higher performance and prepared for longer running events such as half marathon and marathon (Knechtle et al., 2011; Tanda, 2011). Previous studies reported that elite marathoners trained over 160 – 220 km which distributed for 11–14 sessions per week (Casado et al., 2022). Whereas the recreational runners performed quite low training volume that included running distance about 20 – 40 km and training frequency of 2 – 5 sessions per week (Kozlovskaia et al., 2019). Among the recreational runners, distinctions in training distances were also presented as the highly trained runners covered longer mileage than the lower trained runners. Moreover, many studies found associations between training characteristics and race time in marathoners and half marathoners (Fokkema et al., 2020; Friedrich et al., 2014; Knechtle et al., 2011; Rüst et al., 2011; Tanda, 2011; Yamaguchi et al., 2022). The time to finish the race would be shorter if the runners trained more frequently over greater running distances.

In recent years, the 10 km race has become increasingly popular among recreational runners, especially beginners who aimed at finishing the first running race. It is considered as the initial step towards longer race distances. Besides, most long-distance runners usually performed continuous running over 10 km at low intensity in order to improve cardiovascular endurance and also adjust running pace for longer races. A previous study investigating in runners who trained for the national 10 km road race found that the elite runners performed a weekly training with more days and distances than those of the lower performance (Bale et al., 1986). These training variables and physical characteristics such as age, height, body weight and BMI could predict about 80% variances in the race time of all runners. However, participants in this study were well-trained athletes and young healthy people which may be different to most recreational runners. Concerning that recreational runners mostly aged about 30 – 60 years so that they spend much daily time on working and had slightly less time for running. With limited time for training and relatively low performance in recreational runners, understanding the contributions of physical and training characteristics on the running performance would provide useful evidence for designing a training program for recreational runners. Although numerous studies investigating running performances in recreational runners, these were conducted during longer distances such as half-marathon and marathon and their results could not be applied for the 10 km run. Therefore, the objective of this study was to investigate the associations between physical and training characteristics and the running time in recreational runners.

MATERIALS AND METHODS

Participants

Sample size was calculated by the GPower program (version 3.1.9.7), using the effect size of 0.35 and 6 predictors, 57 samples were required for achieving power of 0.90. An additional 5% of the samples were

allocated to prevent dropout which resulted in a total of 60 participants. Thus, sixty runners (30 men and 30 women; age 37.2 ± 8.6 yr, body mass 59.79 ± 10.65 kg; height 166.82 ± 8.06 cm) were recruited in this study. Participants were included if they had the personal best time (PB) in 10 km run of less than 80.00 min. All participants trained regularly for more than 3 months before participating in this study and none had musculoskeletal injuries. All of them received information regarding the experimental procedures and gave written informed consent prior to the test. This study protocol was approved by the institutional ethics committee (Project No.104/2565).

Procedures

All participants were requested to run 10 km on the outdoor track which was carried out in the early morning (6.00 a.m.) of the day. The running test was carried out on separate days for 10-15 runners. Prior to the test, participants provided information regarding physical characteristics (age, body mass, and height) and training aspects (weekly training day, distance and time, years of running experience and numbers of participation in mini-marathon race) and performed routine warm-ups consisting of slow jogging and stretching for 10 min. Then, they were requested to stand in line separately at the starting point and start running upon hearing the instruction. One researcher gave them a verbal signal and recorded the running time by using the stopwatch (Casio, HS-70W, Japan). During the test, participants were asked to keep their usual running pace. The water station was set about 200 m after the starting point so that the participants could have some drinks throughout the test. After finishing the test, all participants performed cooldown and received snacks and energy drinks.

Statistical analysis

Analysis of data was performed using the Open-Source Software R version 4.2.1, R Studio. Descriptive statistics were analysed by using mean and standard deviation. Distribution of physical and training characteristics were determined among runners with different levels of performance defined by the PB. Prior to the analyses, normality of all data was checked by using Z score of the skewness and kurtosis which assumed that $-3.29 < Z < 3.29$ was considered as normal distribution. To investigate relationships between physical and training characteristics and 10 km running time, Pearson's correlation coefficient (r) was determined as trivial ($r \leq 0.1$), small ($0.1 < r \leq 0.3$), moderate ($0.3 < r \leq 0.5$), large ($0.5 < r \leq 0.7$), very large ($0.7 < r \leq 0.9$), and almost perfect ($r > 0.9$). Then, multiple regression analyses were performed to investigate the contributions of the physical and training characteristics (independent variables) on the 10 km running time (dependent variable). Multicollinearity between the variables was accepted if r less than 0.80 and the variance inflation factor was less than 10. Statistical significance was set at $p < .05$.

RESULTS

Based on the PB in 10 km running, participants were classified into three levels of performance including high (37-45 min; n = 14), moderate (46-55 min; n = 23), and low (56-80 min; n = 23). Characteristics of the participants divided by the PB are presented in Table 1. The results showed that physical characteristics were quite different among groups as the high-performance group showed the greatest values of body mass and height than the other groups. However, the BMI (20-22 kg/m^2) and age (36 – 38 years) were relatively similar in all groups. To consider the training characteristics, data were categorized into different ranges. Overall, the high-performance group mostly showed higher ranges of all training characteristics than the other groups. Regarding the weekly training distance, about 86% of the high-performance runners ran over 60-150 km a week while about 57% of the low-performance runners trained 30-59 km a week. However, the moderate-performance runners trained over different ranges with nearly similar proportions; 1-29 km (30%), 30-59 km (35%), and 60-150 km (35%). For the weekly training days, all groups showed higher proportions of training frequency for 4-5 days/week (about 50-65%). These were followed by training 6-7 days/week for

the high- and moderate-performance runners. However, for the low-performance runners, there was similar proportions of training frequency for 1-3 days (52.2%) and 4-5 days (47.8%), none of them trained more than 5 days/week. When considering the numbers of participation in mini-marathon races within a year before taking part in this study, most of the high-performance runners did not compete in this race distance (43%) while small amounts of runners experienced less than 4 races (21%) and 5-9 races (21%), and the remaining 14% participated in more than 10 races. In contrast to the moderate- and low-performance runners, most of them participated less than 4 times in mini-marathon races (39% and 61%, respectively).

Table 1. Physical and training characteristics among three groups of recreational runners.

Characteristic	Running performance level		
	High (n = 14)	Moderate (n = 23)	Low (n = 23)
Physical characteristics			
Age (years)	38.1 ± 7.6	37.5 ± 8.4	36.3 ± 9.5
Body mass (kg)	64.08 ± 9.88	55.37 ± 9.16	61.61 ± 11.28
Height (cm)	171.79 ± 7.66	163.09 ± 6.33	167.52 ± 8.28
Body Mass Index (kg/m^2)	21.59 ± 1.89	20.70 ± 2.34	21.81 ± 2.66
Training characteristics			
Weekly training distance (km/wk)			
1-29	1 (7.1%)	7 (30.4%)	8 (34.8%)
30-59	1 (7.1%)	8 (34.8%)	13 (56.5%)
60-150	12 (85.7%)	8 (34.8%)	2 (8.7%)
Weekly training day (d/wk)			
1-3	0 (0%)	3 (13.0%)	12 (52.2%)
4-5	8 (57.1%)	15 (65.2%)	11 (47.8%)
6-7	6 (42.9%)	5 (21.7%)	0 (0%)
Weekly training time (h/wk)			
1-3	1 (7.1%)	3 (13.0%)	7 (30.4%)
4-5	0 (0%)	6 (26.1%)	6 (26.1%)
6-7	4 (28.6%)	4 (17.4%)	7 (30.4%)
8-10	5 (35.7%)	3 (13.0%)	3 (13.0%)
11-18	4 (28.6%)	7 (30.4%)	0 (0%)
Running experience (years)			
<4	3 (21.4%)	11 (47.8%)	10 (43.5%)
4-6	4 (28.6%)	5 (21.7%)	10 (43.5%)
>6	7 (50.0%)	7 (30.4%)	3 (13.0%)
Numbers of participation in mini-marathon race (time/year)			
0	6 (42.9%)	4 (17.4%)	4 (17.4%)
<4	3 (21.4%)	9 (39.1%)	14 (60.9%)
5-9	3 (21.4%)	4 (17.4%)	3 (13.0%)
>10	2 (14.3%)	6 (26.1%)	2 (8.7%)

Note: Running performance was determined based on the personal best time in 10 km running. Physical characteristics are presented as mean ± standard deviation.

The physical and training characteristics of all recreational runners and their relationships to the 10 km running time are shown in Table 2. The results showed that BMI was significantly correlated with running time (r = 0.275, $p < .05$). Moreover, there were significantly negative relationships between training characteristics and running time ($p < .05$), with large correlations for weekly training distance (r = -0.605) and weekly training day (r = -0.583), and moderate correlations for weekly training time (r = -0.446) and numbers of participation in mini-marathon races (r = -0.311), and small correlation for years of running experience (r = -0.275). However, other physical characteristics including age, body mass and height were not correlated with running time. Thus, all significant parameters including six variables were used as independent variables for further analyses.

Table 2 Physical and training characteristics of recreational runners and their relationships to the 10 km running time.

Parameters	**Mean ± SD**	**Correlation coefficient (r)**	***p*-value**
Age (year)	37.2 ± 8.6	-0.011	.934
Body mass (kg)	59.79 ± 10.65	0.209	.108
Height (cm)	166.82 ± 8.06	0.073	.580
Body Mass Index (kg/m^2)	21.33 ± 2.39	0.275	.033*
Weekly training distance (km/wk)	45.40 ± 28.36	-0.605	<.001**
Weekly training day (d/wk)	4.6 ± 1.1	-0.583	<.001**
Weekly training time (h/wk)	7.28 ± 3.95	-0.446	<.001**
Running experience (year)	4.7 ± 2.9	-0.275	.034*
Numbers of participation in mini-marathon race (time/year)	4.4 ± 5.6	-0.311	.016*

*Note: * p < .05, ** p < .01.*

Table 3 Associations between physical and training indicators and 10 km running time using multivariable linear regression analysis.

Predictors	**B**	**Std. Error**	**β**	**95%CI**	**t**	***p*-value**
Constant	71.900	12.789				.001**
Body Mass Index	0.751	0.501	0.143	-0.25, 1.76	1.50	.140
Weekly training distance	-0.188	0.059	-0.425	-0.31, -0.07	-3.22	.002**
Weekly training day	-3.048	1.433	-0.272	-5.92, -0.17	-2.13	.038*
Weekly training time	0.302	0.395	0.095	-0.49, 1.09	0.76	.448
Running experience	-0.982	0.404	-0.227	-1.79, -0.17	-2.43	.018*
Numbers of participation in mini-marathon race	-0.729	0.208	-0.326	-1.15, -0.31	-3.51	.001**

*Note: B = unstandardized coefficient, Std. Error = standard error of unstandardized coefficient, ß = standardized coefficient, t = t statistic value, CI = confidence interval; * p < .05, ** p < .01.*

For the multiple regression analysis, the results meet the underlying assumptions showing by r < 0.80 for all variables and variance inflation factor < 2. When six variables were inserted into a multiple regression model, results showed that these variables could predict 57% of variances in the running time (r = 0.760, $r^2 = 0.577$, adjusted $r^2 = 0.529$, $F_{(6,53)} = 12.04$, $p < .01$) (Table 3). Among these variables, the weekly training distance showed the greatest effect on running time, followed by numbers of participation in mini-marathon races, weekly training day, running experience, BMI, and weekly training time. From the analyses, the first four variables were significantly associated with running time ($p < .001$) whereas the BMI and weekly training time showed no significant effects. According to these results, the 10 km running time for the recreational runners

could be predicted using the following equation: running time (min) = 71.90 + 0.751(BMI) – 0.188(weekly training distance) – 3.048(weekly training day) + 0.302(weekly training time) – 0.982(running experience) – 0.729(numbers of participation in mini-marathon race).

DISCUSSION

The purpose of this study was to investigate the predictors for 10 km running time in recreational runners. The findings showed that physical characteristics (BMI) and training characteristics (weekly training distance, weekly training day, weekly training time, running experience, and numbers of participation in mini-marathon races) were significantly associated with running time. These variables could predict 57% of variances in the running time. Among all variables, the weekly training distance showed the greatest effect on running time. These were consistent with previous studies investigating elite and well-trained athletes during half marathon and full marathon (Bale et al., 1986; Nikolaidis & Knechtle, 2023; Tanda & Knechtle, 2013; Zillmann et al., 2013). Moreover, a previous research found that significant effect of training distance was clearly presented only if running greater than 10 km per session (Yamaguchi et al., 2022). In the present study, all runners ran about 45 km per week which was above this lowest range and probably performed long-slow run training. There has been shown that many recreational runners performed the long-slow run or continuous run that is executed at low intensity as it could improve both running performance and health status (Billat, 2001; Boullosa et al., 2020). Previous report stated that physiological adaptations may be more pronounced during long run training since muscles utilised more energy that would induce an increased mitochondria and muscle size as well as increase in slow twitch fibres. These changes could affect oxygen consumption and running economy that requires for endurance training (Nikolaidis & Knechtle, 2023). Additionally, these types of training would improve cardiovascular endurance and muscle strength thereby enhancing cardiovascular and muscular fitness required for long distance running (Feito & Fountaine, 2022). Thus, it is assumed that with high levels of physical fitness, runners could achieve the shortest time as needed.

When considering other aspects of the training program, the present study found the effect of weekly training day on the running time. This variable is one of the training elements that many runners use to consider training volume. From our results, the weekly training day had positive correlations with the weekly training distance ($r = 0.659$). Furthermore, most runners regularly trained over 4-5 days per week with relatively long distance. It might be that runners planned the total weekly distance and split the training days with proper distances to avoid overtraining and risk of musculoskeletal injuries.

Regarding the years of running experience and numbers of participation in the mini-marathon races, these variables had negative correlations with the running time. There has been shown that elite runners who had more years (about 8 years) of running experiences ran faster than those of the lower-levels runners (Bale et al., 1986). In the present study, most of the high-performance runners experienced running for more than 6 years while the moderate- and low-performance runners had slightly less experience (less than 4 years). Throughout the years, runners would improve their performance and thus achieve shorter run time. In addition, running experience can be attained by participation in the races. From our results, most runners in the moderate- and low-performance levels participated in mini-marathon races less than 4 times a year while some of the high-performance runners did not. With high demand on the competition that require longer time for recovery, it might be that the high-performance runners had determined a yearly plan for the major running races that they aimed at achieving the new PB. Whereas for the moderate- and low-performance runners, the races may be one of the training plans that help increase running distance and thus improve the running time.

From the remaining variables of prediction, the weekly training time and BMI did not show significant effects on the running time. Regarding the effect of training time, similar results were found as the previous studies in half marathoners and marathoners (Friedrich et al., 2014; Hagan et al., 1987). Although the training time is a key aspect of training program, it involves not only long-distance running but also other activities such as warmups, drills, and cooldown. For the effect of the BMI, previous reports from a wide range of BMI showed significant associations with the race time (Nikolaidis & Knechtle, 2023; Rüst et al., 2011; Tanda, 2015; Tanda & Knechtle, 2013; Zillmann et al., 2013). This was different from our results since all runners had a close range of BMI at normal level (about 21 kg/m^2) which probably limited the potential of prediction.

Practical applications

From our findings, it can be suggested that recreational runners should plan a weekly training program with more than 45 km long-distance run by splitting over 4-5 days per week. Since experiences derived from training and running races associated with the running time, runners should participate in the long-distance running events at least once a year. Although the weekly training time and BMI demonstrated small effects, running over 7 hours per week, and maintaining the BMI within normal range are recommended. Of importance, recreational runners, especially people who have just begun running should determine which training characteristics need to be focused during training.

CONCLUSIONS

Our study found that both physical and training characteristics correlated with the race time. About 57% of variances in the running time could be predicted by BMI, weekly training distance, weekly training day, weekly training time, running experience, and numbers of participation in mini-marathon race. Among these predictors, the weekly training distance had the greatest effect on running time. With the negative effects of weekly training distance and training day, these can be suggested that training methods involving long-distance running and more days of weekly training would result in shorter running time. To achieve efficient performance, recreational runners should also participate in the mini-marathon races at least once a year as well as attain experience in long-distance running using appropriate training methods.

AUTHOR CONTRIBUTIONS

Study conception and design: Sutima Suwankan and Suriyan Suwankan; Data collection: Sutima Suwankan and Suriyan Suwankan; Analysis and interpretation of results: Sutima Suwankan, Suriyan Suwankan, and Apiluk Theanthong; Writing – original draft: Sutima Suwankan and Suriyan Suwankan; Writing – review and editing: Sutima Suwankan, Suriyan Suwankan, Supatcharin Kemarat, and Apiluk Theanthong; Supervision: Supatcharin Kemarat and Apiluk Theanthong. All authors have read and agreed to the published version of the manuscript.

SUPPORTING AGENCIES

The authors gratefully acknowledge the financial support provided by the Faculty of Allied Health Science Research Fund, Contract No. AHSRS 5/2565.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

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