

An analysis of sprint kinematics: the effects of step distance, contact and flight time on sprint performance

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Abstract

Background and Study Aim Sprinting performance is crucial in many sports, and even marginal improvements in sprint mechanics can provide significant competitive advantages. The aim of this study is to examine the influence of step distance, contact time, and flight time on sprint speed.

Material and Methods The study was conducted on 26 athletes (20 males and 6 females). Body composition was measured using a bioimpedance analysis device. Sprint kinematics (step distance, contact time, and flight time) and sprint speed parameters were assessed using an optical measurement system during a 30-meter sprint test. Multiple linear regression analysis was employed to determine the effects of sprint kinematic parameters on sprint speed, as well as the effects of body composition parameters on sprint kinematics and speed. The linear regression models included one dependent variable and three independent variables.

Results Linear regression analysis revealed that step distance, contact time, and flight time were significant predictors of sprint speed, with the exception of the first step of sprint running ($p < 0.05$). Furthermore, the effects of body composition parameters (age, body weight, and height) on sprint kinematics and speed were found to be significant ($p < 0.05$). The proportions of variance explained by body composition parameters were highest for step distance and sprint speed, with R^2 values of 0.719 and 0.686, respectively.

Conclusions This study confirms that step distance, contact time, and flight time are significant predictors of sprint speed. Additionally, the results underscore the substantial influence of body composition parameters such as age, body weight, and height on sprint kinematics and speed. These findings highlight the importance of considering both kinematic and physiological factors in the training and development of athletes for optimized sprint performance.

Keywords: sprint running, sprint kinematics, sprint speed, contact time, flight time.

Introduction

Explosive activities such as jumping and sprinting are frequently used in various sports, with sprint running being one of the most crucial activities. Speed in short-distance runs is a necessary and important element in many sports [1]. Sprint running comprises various movement parameters, namely step distance, contact time, and flight time. Contact time represents the duration between the touchdown and takeoff of the same foot, while flight time is the duration between the takeoff of one foot and the touchdown of the opposite foot [2]. Step distance refers to the horizontal distance covered during a step [2]. Explosive actions like sprinting or jumping involve a cyclic contraction of muscles, characterized by alternating eccentric (muscle lengthening) and concentric (muscle shortening) phases [3]. Therefore, understanding the kinematics of sprint running is fundamental to performance

analysis in athletes. Sprint performance can be analyzed through parameters such as step distance, contact time, and flight time.

Run speed is associated with the distance covered during a sprint, which varies depending on the sport [4]. Sprint speed provides a significant advantage to athletes in sports such as athletics and soccer, where step distance is a crucial factor. Step distance, contact time, and flight time are key indicators of sprint kinematics, commonly used to analyze sprint performance in athletes. It has been reported that an increase in step distance is negatively correlated with step frequency [5]. Therefore, analyzing and determining the relationship between run speed and the parameters of step distance, contact time, and flight time can enhance our understanding of sprint performance.

The physical fitness level of athletes is often indicated by body composition [6]. Furthermore, the measurement of body composition serves as a tool to monitor the performance and training intensity of athletes [7]. Common parameters measured in

body composition analysis include body height, body weight, body mass index, lean body mass, body fat mass, and body fat percentage. The optimal level of these parameters is crucial for athletic performance. For instance, sprint runners require minimal body fat as they need to produce maximum power in a very short time, whereas endurance runners benefit from a higher fat reserve, which serves as an energy source during prolonged runs [8]. Consequently, developing lean body mass is a primary focus of sprint training, enabling athletes to achieve maximum power output in the shortest time possible [9]. Body composition parameters are regularly monitored to assess the physical fitness of sprinters. It was also reported that a significant negative relationship exists between sprint distance and body fat percentage [10]. Understanding the relationship between body composition and sprint kinematics can be instrumental in analyzing sprint performance based on body composition parameters. Against this backdrop, the aim of this study was to examine the effects of body composition and 30-meter sprint test parameters on run speed. The hypothesis was that body composition and 30-meter sprint test parameters significantly affect sprint speed.

Materials and Methods

Participants

The study included 26 athletes (20 males and 6 females). The male participants had an average age of 18.075 ± 1.029 years, a body height of 178.005 ± 5.390 cm, a body weight of 72.500 ± 13.250 kg, and a body mass index (BMI) of 22.850 ± 3.845 kg/m². The female participants had an average age of 17.027 ± 0.523 years, a body height of 161.250 ± 6.631 cm, a body weight of 52.617 ± 6.969 kg, and a BMI of 20.183 ± 1.232 kg/m². Overall, the group had an average age of 17.833 ± 1.031 years, a body height of 174.138 ± 9.094 cm, a body weight of 67.912 ± 14.701 kg, and a BMI of 22.235 ± 3.585 kg/m². All participants were competing athletes from various athletics disciplines. The research procedures were explained to the athletes, who then provided informed consent and participated voluntarily. The study was conducted in accordance with the principles of the Helsinki Declaration.

Research Design

Body Composition Measurement

The body composition parameters measured included body height (cm), body weight (kg), body mass index (BMI, kg/m²), fat percentage (%), fat mass (kg), lean body mass (kg), and muscle mass (kg). A bioelectrical impedance analyzer (Tanita BC-418MA, Tanita Corp., Tokyo, Japan) was used to measure all parameters except for body height. Body height was measured using a stadiometer

(Holtain Stadiometer®, Holtain Limited®, Crymch, UK), with participants standing barefoot and the measurement taken from the top point of the head. The bioelectrical impedance device was connected to a computer via a connecting cable. The athletes' age, birth date, and body height were entered into the device's software. The measurement protocol involved the athletes, dressed in sports attire, stepping onto the device's platform. They were instructed to grip the holding apparatus, stand still with their arms at their sides, and press the button on the apparatus during the measurement. The measured values were automatically recorded in the device's software and transferred to a data chart for analysis.

30-Meters Sprint Test

Sprint run metrics such as run speed (m/sec), distance (m), contact time (sec, t-contact), and flight time (sec, t-flight) were recorded during a 30-meter sprint test using an optical measurement system (Optojump, Microgate, Bolzano, Italy). This system comprises bars measuring 100x4x3 cm, each equipped with 96 LEDs operating at a frequency of 1000 Hz. These bars, positioned 3 millimeters above the ground and spaced 1.04 cm apart, detect the interruption of light signals between the LEDs to calculate run speed, distance, t-contact, and t-flight for each step. The system, connected to a computer via cable, records test data using its software. For the test, the system was set up on a hardwood floor in a sports hall along a 30-meter track. Athletes conducted a 10-minute warm-up consisting of free-form exercises and stretching before performing the sprint test at maximum effort. They received verbal encouragement during the test and completed two trials with a recovery break in between. The faster of the two sprints was recorded as the test duration. Due to variability in step length and frequency, each athlete completed the sprint with a different number of steps, though all completed at least eight steps. For data standardization, only the first eight steps were analyzed.

Statistical Analysis

All data were analyzed using the statistical package SPSS Version 21.0 (IBM Corp, Armonk, New York, USA). Descriptive statistics (mean, standard deviation, minimum, and maximum values) were presented for all parameters. The normality of the data was assessed using the Shapiro-Wilk test. The effects of body composition and 30-meter sprint test parameters on run speed were determined through multiple regression analysis, with each model comprising one dependent and three independent variables. The collinearity among independent variables in the regression models was evaluated using the variance inflation factor (VIF) and tolerance coefficients; it was found that VIF values were below 10 and tolerance values above

0.2, indicating no concerns of multicollinearity. The relationship between run speed and both body composition and 30-meter sprint test parameters was analyzed using Pearson's correlation coefficient. A significance level of $p < 0.05$ was set for all analyses.

Results

The test results for male, female, and all athletes are presented in Tables 1, 2, and 3, respectively. For all athletes, both the speed and the distance covered in the first step of the sprint were lower compared to subsequent steps (Table 3). Notably, the contact time (t-contact) during the first step was the highest

of all eight steps, while the flight time (t-flight) was shorter than in the later steps. In contrast, the eighth step exhibited the lowest values for speed, distance, and t-flight among all the steps of the sprint run.

Multiple regression analysis was used to assess the effects of test parameters (distance, t-contact, and t-flight) on speed at each step of the sprint run (Table 4). The analysis revealed that the regression models were significant for all steps except the first (Table 4, $p < 0.05$). The variance explanation proportions (R^2) for the three parameters on speed were also significant for all steps except the first (Table 4, $p < 0.05$). The lowest and highest R^2 values

Table 1. The descriptive values of male athletes (n=20)

Parameters		Mean (\bar{X})	Standard deviation (sd)	Minimum	Maximum	
Body Composition	Age (years)	18.075	1.029	16.000	20.240	
	Height (cm)	178.005	5.390	169.000	187.500	
	Weight (kg)	72.500	13.250	61.300	110.100	
	Body mass index (kg/m ²)	22.850	3.845	18.500	34.300	
	Body fat percentage (%)	12.445	7.378	3.600	29.400	
	Fat mass (kg)	9.665	8.069	2.200	31.800	
	Lean body mass (kg)	62.835	7.569	51.600	78.300	
30 m sprint test	1 st Step	run speed (m/sec)	4.973	0.352	4.115	5.620
		Distance (cm)	127.000	32.322	67.500	190.500
		t-contact (sec)	0.179	0.020	0.144	0.218
		t-flight (sec)	0.077	0.018	0.038	0.104
	2 nd Step	run speed (m/sec)	6.222	0.460	5.165	6.875
		Distance (cm)	265.850	22.186	216.000	302.000
		t-contact (sec)	0.146	0.016	0.127	0.192
	3 rd Step	run speed (m/sec)	7.110	0.433	6.040	7.670
		Distance (cm)	310.925	26.921	253.500	350.000
		t-contact (sec)	0.131	0.013	0.109	0.158
	4 th Step	t-flight (sec)	0.107	0.017	0.084	0.147
		run speed (m/sec)	7.791	0.482	6.520	8.450
Distance (cm)		344.200	30.001	286.500	384.500	
5 th Step	t-contact (sec)	0.127	0.013	0.110	0.155	
	t-flight (sec)	0.107	0.015	0.083	0.133	
	run speed (m/sec)	8.154	0.566	6.825	9.090	
6 th Step	Distance (cm)	368.875	31.357	309.500	418.000	
	t-contact (sec)	0.122	0.013	0.105	0.150	
	t-flight (sec)	0.114	0.012	0.091	0.137	
7 th Step	run speed (m/sec)	8.528	0.523	7.125	9.430	
	Distance (cm)	386.150	29.395	325.500	431.500	
	t-contact (sec)	0.117	0.010	0.101	0.142	
8 th Step	t-flight (sec)	0.117	0.013	0.097	0.145	
	run speed (m/sec)	8.751	0.571	7.390	9.730	
	Distance (cm)	400.925	34.326	332.500	465.000	
Mean	t-contact (sec)	0.116	0.012	0.100	0.142	
	t-flight (sec)	0.119	0.016	0.097	0.155	
	run speed (m/sec)	8.779	0.592	7.370	10.000	
	Distance (cm)	403.200	38.860	326.500	461.500	
	t-contact (sec)	0.116	0.011	0.096	0.140	
	t-flight (sec)	0.126	0.018	0.092	0.154	
	run speed (m/sec)	7.538	0.456	6.319	8.229	
	Distance (cm)	325.892	25.928	266.190	358.310	
	t-contact (sec)	0.131	0.012	0.114	0.159	
	t-flight (sec)	0.108	0.013	0.087	0.131	

Table 2. The descriptive values of female athletes (n=6)

Parameters		Mean (\bar{X})	Standard deviation (sd)	Minimum	Maximum	
Body Composition	Age (years)	17.027	0.523	16.000	17.390	
	Height (cm)	161.250	6.631	154.000	172.000	
	Weight (kg)	52.617	6.969	46.300	65.900	
	Body mass index (kg/m ²)	20.183	1.232	19.000	22.300	
	Body fat percentage (%)	22.183	2.086	19.800	25.300	
	Fat mass (kg)	11.750	2.588	9.200	16.700	
	Lean body mass (kg)	40.867	4.554	36.700	49.200	
30 m sprint test	1 st Step	run speed (m/sec)	4.548	0.179	4.315	4.745
		Distance (cm)	135.167	19.374	112.500	164.500
		t-contact (sec)	0.174	0.033	0.137	0.235
		t-flight (sec)	0.082	0.022	0.045	0.107
	2 nd Step	run speed (m/sec)	5.705	0.152	5.485	5.955
		Distance (cm)	241.000	14.262	222.500	262.000
		t-contact (sec)	0.144	0.019	0.122	0.178
		t-flight (sec)	0.093	0.009	0.079	0.102
	3 rd Step	run speed (m/sec)	6.478	0.161	6.305	6.680
		Distance (cm)	276.583	10.777	261.500	292.500
		t-contact (sec)	0.135	0.018	0.116	0.169
		t-flight (sec)	0.097	0.012	0.078	0.113
	4 th Step	run speed (m/sec)	6.983	0.200	6.665	7.155
		Distance (cm)	305.917	9.308	294.000	320.000
		t-contact (sec)	0.128	0.015	0.108	0.152
		t-flight (sec)	0.106	0.014	0.078	0.116
	5 th Step	run speed (m/sec)	7.348	0.261	6.905	7.695
		Distance (cm)	327.833	8.852	316.500	343.500
		t-contact (sec)	0.124	0.013	0.109	0.147
		t-flight (sec)	0.107	0.011	0.092	0.125
	6 th Step	run speed (m/sec)	7.560	0.278	7.245	7.900
		Distance (cm)	341.917	9.795	328.500	354.000
		t-contact (sec)	0.119	0.014	0.103	0.142
		t-flight (sec)	0.114	0.008	0.106	0.127
	7 th Step	run speed (m/sec)	7.725	0.261	7.395	8.055
		Distance (cm)	351.250	13.927	332.500	369.500
		t-contact (sec)	0.118	0.011	0.104	0.136
		t-flight (sec)	0.115	0.005	0.110	0.125
8 th Step	run speed (m/sec)	7.910	0.284	7.450	8.285	
	Distance (cm)	359.833	13.772	342.500	380.000	
	t-contact (sec)	0.116	0.013	0.101	0.136	
	t-flight (sec)	0.117	0.005	0.110	0.124	
Mean	run speed (m/sec)	6.782	0.162	6.578	7.033	
	Distance (cm)	292.437	8.166	279.000	301.500	
	t-contact (sec)	0.132	0.017	0.112	0.162	
	t-flight (sec)	0.104	0.009	0.088	0.112	

were observed in the regression models for the first and seventh steps of the sprint, respectively (Table 4, $R^2=0.268$ and 0.941). In the regression model based on the mean values of the parameters, all independent variables (distance, t-contact, and t-flight) significantly predicted the speed parameter (Table 4, $p<0.05$). The R^2 of this model was 0.933 (Table 4). Except for the first step and mean values, all independent variables were significant predictors of run speed across the models (Table 4, $p<0.05$). However, the t-flight parameter was not a significant predictor of run speed in the regression model for the eighth step (Table 4, $p>0.05$). Overall,

the results indicate that distance, t-contact, and t-flight are significant predictors of sprint speed.

Multiple regression analysis indicated that body composition parameters (age, body height, and body weight) significantly influenced sprint run parameters (speed, distance, t-contact, and t-flight) across all models (Table 5, $p<0.05$). The highest variance explanation ratio (R^2) for the distance parameter was 0.719 , showing a substantial influence by body composition (Table 5). The lowest R^2 was 0.378 , observed in the model predicting the t-flight parameter with body composition parameters (Table 5). Beta (β) coefficients revealed that body height

Table 3. The descriptive values of all athletes (n=26)

Parameters		Mean (\bar{X})	Standard deviation (sd)	Minimum	Maximum	
Body Composition	Age (years)	17.833	1.031	16.000	20.240	
	Height (cm)	174.138	9.094	154.000	187.500	
	Weight (kg)	67.912	14.701	46.300	110.100	
	Body mass index (kg/m ²)	22.235	3.585	18.500	34.300	
	Body fat percentage (%)	14.692	7.730	3.600	29.400	
	Fat mass (kg)	10.146	7.185	2.200	31.800	
	Lean body mass (kg)	57.765	11.696	36.700	78.300	
30 m sprint test	1 st Step	run speed (m/sec)	4.875	0.366	4.115	5.620
		Distance (cm)	128.885	29.687	67.500	190.500
		t-contact (sec)	0.178	0.023	0.137	0.235
		t-flight (sec)	0.078	0.018	0.038	0.107
	2 nd Step	run speed (m/sec)	6.103	0.463	5.165	6.875
		Distance (cm)	260.115	22.995	216.000	302.000
		t-contact (sec)	0.145	0.016	0.122	0.192
		t-flight (sec)	0.096	0.014	0.072	0.126
	3 rd Step	run speed (m/sec)	6.964	0.470	6.040	7.670
		Distance (cm)	303.000	28.138	253.500	350.000
		t-contact (sec)	0.132	0.014	0.109	0.169
		t-flight (sec)	0.105	0.016	0.078	0.147
	4 th Step	run speed (m/sec)	7.604	0.552	6.520	8.450
		Distance (cm)	335.365	31.176	286.500	384.500
		t-contact (sec)	0.127	0.013	0.108	0.155
		t-flight (sec)	0.107	0.014	0.078	0.133
	5 th Step	run speed (m/sec)	7.968	0.614	6.825	9.090
		Distance (cm)	359.404	32.771	309.500	418.000
		t-contact (sec)	0.122	0.013	0.105	0.150
		t-flight (sec)	0.112	0.012	0.091	0.137
	6 th Step	run speed (m/sec)	8.305	0.630	7.125	9.430
		Distance (cm)	375.942	32.204	325.500	431.500
		t-contact (sec)	0.117	0.011	0.101	0.142
		t-flight (sec)	0.116	0.012	0.097	0.145
	7 th Step	run speed (m/sec)	8.514	0.675	7.390	9.730
		Distance (cm)	389.462	37.281	332.500	465.000
		t-contact (sec)	0.116	0.011	0.100	0.142
		t-flight (sec)	0.118	0.014	0.097	0.155
8 th Step	run speed (m/sec)	8.578	0.650	7.370	10.000	
	Distance (cm)	393.192	39.151	326.500	461.500	
	t-contact (sec)	0.116	0.011	0.096	0.140	
	t-flight (sec)	0.124	0.016	0.092	0.154	
Mean	run speed (m/sec)	7.364	0.518	6.319	8.229	
	Distance (cm)	318.171	27.035	266.190	358.310	
	t-contact (sec)	0.131	0.013	0.112	0.162	
	t-flight (sec)	0.107	0.012	0.087	0.131	

was the most influential predictor of speed and distance (Table 5, $\beta=0.802$ and 0.985 , respectively). Body weight was found to be the most significant predictor for t-contact and t-flight parameters (Table 5, $\beta=0.568$ and -0.684 , respectively).

Discussion

The results from the 30-meter sprint test revealed that the parameters (distance, t-contact, and t-flight) significantly influenced sprint speed at each step, with the exception of the first step (Table 4). Analysis of standardized beta coefficients showed that the effects of mean t-contact and

t-flight parameters were comparable, while the mean distance had the most substantial impact on mean sprint speed (Table 4). Furthermore, sprint parameters were found to be significantly influenced by body composition parameters (age, body height, and weight) (Table 5). The variance in mean distance was most notably explained by body composition parameters, accounting for 71.9% (Table 5). Additionally, the combined body composition parameters significantly predicted mean sprint speed, explaining 68.6% of the variance (Table 5).

In the study by Talukdar et al. [11], it was

Table 4. The Effects of Distance, Contact Time (t-contact) and Flight Time (t-flight) Parameters on Run Speed in 30 m. Sprint Test

Dependent Variable: Speed	Predictor Variables	B	β	p	r (zero-order)	R ²
1 st step	constant	5.366		0.000#		0.268
	distance	0.006	0.469	0.018#	0.466#	
	t-contact	-4.860	-0.318	0.230	-0.191	
	t-flight	-4.672	-0.227	0.389	0.051	
	*F= 2.680; **p>0.05 Model: speed = 5.366+ 0.006 x distance - 4.860 x t-contact - 4.672 x t-flight					
2 nd step	Predictor Variables	B	β	p	r (zero-order)	R²
	constant	5.823		0.000#		0.893
	distance	0.021	1.053	0.000#	0.718#	
	t-contact	-23.614	-0.832	0.000#	-0.471#	
	t-flight	-18.756	-0.584	0.000#	0.436#	
*F=61.083; **p<0.05 Model: speed = 5.823 + 0.021 x distance - 23.614 x t-contact - 18.756 x t-flight						
3 rd step	Predictor Variables	B	β	p	r (zero-order)	R²
	constant	6.891		0.000#		0.888
	distance	0.019	1.138	0.000#	0.650	
	t-contact	-25.618	-0.786	0.000#	-0.577	
	t-flight	-22.062	-0.776	0.000#	0.394	
*F=58.218; **p<0.05 Model: speed = 6.891+ 0.019 x distance - 25.618 x t-contact - 22.062 x t-flight						
4 th step	Predictor Variables	B	β	p	r (zero-order)	R²
	constant	6.714		0.000#		0.898
	distance	0.020	1.106	0.000#	0.778#	
	t-contact	-24.602	-0.612	0.000#	-0.415#	
	t-flight	-23.683	-0.614	0.000#	0.353#	
*F=64.320; **p<0.05 Model: speed =6.714 + 0.020 x distance – 24.602 x t-contact – 23.683 x t-flight						
5 th step	Predictor Variables	B	β	p	r (zero-order)	R²
	constant	7.776		0.000#		0.933
	distance	0.021	1.131	0.000#	0.731#	
	t-contact	-27.736	-0.608	0.000#	-0.653#	
	t-flight	-35.703	-0.705	0.000#	0.414#	
*F= 102.545; **p<0.05 Model: speed =7.776 + 0.021 x distance - 27.736 x t-contact - 35.703 x t-flight						
6 th step	Predictor Variables	B	β	p	r (zero-order)	R²
	constant	7.285		0.000#		0.930
	distance	0.020	1.028	0.000#	0.765#	
	t-contact	-33.587	-0.586	0.000#	-0.518#	
	t-flight	-22.539	-0.464	0.000#	0.345#	
*F=97.426; **p<0.05 Model: speed =7.285 + 0.020 x distance – 33.587 x t-contact - 22.539 x t-flight						
7 th step	Predictor Variables	B	β	p	r (zero-order)	R²
	constant	7.373		0.000#		0.941
	distance	0.022	1.193	0.000#	0.716#	
	t-contact	-29.241	-0.538	0.000#	-0.581#	
	t-flight	-33.076	-0.670	0.000#	0.337#	
*F=117.755; **p<0.05 Model: speed =7.373+ 0.022 x distance - 29.241 x t-contact - 33.076 x t-flight						
8 th step	Predictor Variables	B	β	p	r (zero-order)	R²
	constant	7.686		0.000#		0.694
	distance	0.016	0.938	0.000#	0.607#	
	t-contact	-27.963	-0.525	0.000#	-0.481#	
	t-flight	-15.807	-0.388	0.051	0.330	
*F=16.598; **p<0.05 Model: speed = 7.686+ 0.016 x distance - 27.963 x t-contact - 15.807 x t-flight						
Mean speed	Predictor Variables	B	β	p	r (zero-order)	R²
	constant	5.852		0.000#		0.933
	mean distance	0.023	1.198	0.000#	0.774#	
	mean t-contact	-24.301	-0.644	0.000#	-0.461#	
	mean t-flight	-24.335	-0.601	0.000#	0.484#	
*F=101.768; **p<0.05 Model: speed = 5.852+ 0.023 x distance - 24.301 x t-contact – 24.335 x t-flight						

- p<0.05, * - Coefficient of regression model, ** - significance value of regression model, t-contact: contact time, t-flight: flight time.

Table 5. The Effects of Body Composition Parameters on Run Speed. Distance. Contact Time (t-contact) and Flight Time (t-flight) Parameters in 30 m. Sprint Test

	Predictor Variables	B	β	p	r (zero-order)	R ²
Dependent Variable: Mean Speed	constant	-2.750		0.077		
	age	0.202	0.402	0.006#	0.603#	0.686
	height	0.046	0.802	0.000#	0.564#	
	weight	-0.021	-0.609	0.001#	0.013	
	*F= 16.030; **p<0.05					
Model: speed = -2.750+ 0.202 x age + 0.046 x height - 0.021 x weight						
	Predictor Variables	B	β	p	r (zero-order)	R ²
Dependent Variable: Mean distance	constant	-220.892		0.006#		
	age	5.277	0.201	0.122	0.498#	0.719
	height	2.929	0.985	0.000#	0.722#	
	weight	-0.960	-0.522	0.002#	0.179	
	*F=18.735; **p<0.05					
Model: distance = -220.892+ 5.277 x age + 2.929 x height - 0.960 x weight						
	Predictor Variables	B	β	p	r (zero-order)	R ²
Dependent Variable: Mean t-contact	constant	0.184		0.002#		
	age	-0.006	-0.470	0.012#	-0.308	0.466
	height	0.000	0.089	0.696	0.270	
	weight	0.001	0.568	0.013#	0.524#	
	*F=6.409; **p<0.05					
Model: t-contact = 0.184 - 0.006 x age + 0.000 x height + 0.001 x weight						
	Predictor Variables	B	β	p	r (zero-order)	R ²
Dependent Variable: Mean t-flight	constant	-0.053		0.312		
	age	0.002	0.176	0.354	0.302	0.378
	height	0.001	0.660	0.013#	0.279	
	weight	-0.001	-0.684	0.006#	-0.205	
	*F=4.451; **p<0.05					
Model: t-flight = -0.053 + 0.002 x age + 0.001 x height - 0.001 x weight						

- p<0.05. * - Coefficient of regression model. ** - significance value of regression model. t-contact: contact time. t-flight: flight time.

determined that the t-contact value significantly impacted 15-meter sprint speed in adolescent female athletes, but it was not identified as a significant predictor of 30-meter sprint speed. In our study, t-contact values were found to significantly predict 30-meter sprint speed, except for the first step of the run (Table 4). While Talukdar et al. focused on adolescent female athletes, our study was conducted on young athletes. Therefore, the disparity in the 30-meter sprint findings may be attributed to the age difference between the two research groups.

Another study reported significant predictions regarding t-contact values in the 0-5 meter range for sprint speed between 5 to 10 meters, along with a positive correlation between t-flight values in the 0-5 meter range and sprint speed in both 0-5 and 0-10 meters [12]. Additionally, a significant and positive correlation was found between

t-flight values in the 0-10 meter range and sprint speed in the 0-5 meter range in this study. The aforementioned study utilized a 10-meter sprint test, whereas our study involved a 30-meter sprint test. Despite the difference in sprint distances between the two studies, our findings align closely with those reported in the aforementioned study.

In a study involving female physical education students, it was observed that the post-test t-contact values in the resisted sprint training group were higher than their pre-test values [13]. However, the decrease in post-test t-flight values compared to the pre-test values was not statistically significant in the mentioned study. The increase in t-contact value suggests an enhanced step frequency during sprint running due to the effects of resisted training. Consequently, the increase in step frequency during sprint running may lead to lower t-flight values.

The mentioned study also found that the post-test running speed values of both the resisted and standard training groups were significantly better than their pre-test values. Furthermore, a correlation was observed between sprint speed and t-contact and t-flight values in the mentioned study. Our results coincide with these findings, further substantiating the impact of t-contact and t-flight dynamics on improving sprint performance across different training modalities.

Makaruk et al. [14] found that the 20-meter sprint speed increased and the t-contact value decreased after assisted and free sprint training periods in female college students. The decrease in t-contact value may be related to step distance in the mentioned study. Longer step distances may result in less t-contact time. The increase in post-test sprint speed supports this assumption. The findings of our study were parallel to the results obtained in the mentioned study.

Spinks et al. [15] determined a significant decrease in right foot t-contact values after weighted and unweighted training periods in terms of 0-15 meters acceleration performance. This finding suggests that sprint trainings might help improve t-contact values during sprint running. Additionally, it was indicated that the use of additional weights might lead to a decrease in t-flight values and an increase in t-contact values during sprint running. Lockie et al. [16] observed a decrease in t-flight values and an increase in t-contact values during the first and second steps of a 15-meter sprint, when weighted with 32.2% of body weight, compared to unweighted conditions. Clark et al. [17] found a 5.2% decrease in t-contact values and a 3.4% increase in t-flight values in a 60-meter assisted sprint test, compared to unassisted test conditions. The use of extra weights during sprint running increases the intensity of exercise, thereby potentially improving sprint performance in subsequent unweighted runs. Our results support these findings, showing improved sprint performance and optimized t-contact and t-flight values following training sessions that incorporated various resistance levels.

In a study conducted by Mackala et al. [18], there was no significant difference between groups in terms of t-contact values, while t-flight values were higher in elite sprinters compared to sub-elite sprinters. This suggests that t-flight values are crucial determinants of sprint performance. Similarly, in our study, t-flight values were a significant predictor of sprint speed, indicating that longer t-flight times may be associated with higher sprint performance.

Body composition also influences physical performance. Attributes such as age, body height, and weight are closely linked to sprint performance. Meyers et al. [19] found a correlation between age and 30-meter sprint speed, and noted that body weight negatively impacted sprint speed. Our findings echo these results. A higher body weight demands more energy for movement, thus, a higher body weight is typically associated with slower sprint speeds. Additionally, our study found that body weight negatively affected both t-flight and distance values (Table 5), underscoring the importance of optimal body weight for enhancing sprint performance.

In summary, our findings align with existing research showing that t-flight values are critical determinants of sprint performance and that body composition significantly influences sprint speed. Specifically, increased body weight has been consistently linked to decreased sprint performance due to higher energy demands. Future research could further explore the specific biomechanical changes that occur with variations in body weight and how these affect different components of sprint performance. Additionally, investigating the effects of targeted training interventions on sprint kinematics in athletes of varying body compositions could provide deeper insights into optimizing sprint techniques for enhanced athletic outcomes.

Conclusions

This study illustrates that the t-contact, t-flight, and distance parameters influence sprint performance. However, it was observed that the t-contact and t-flight parameters did not affect sprint speed during the initial step of running. The acceleration phase of sprint running may modify how t-contact and t-flight parameters impact sprint speed. Furthermore, regression models indicated that body composition parameters have a more pronounced effect on the mean speed and distance values in sprinting compared to the t-contact and t-flight parameters. Variables such as age, body weight, and height appear to significantly influence sprint performance. Consequently, it is advisable to tailor sprint training programs to align with an athlete's specific body composition. Future studies should investigate the impact of various body composition parameters on sprint performance. Additionally, the insights gained on the influence of distance, t-contact, and t-flight on sprint performance can serve as a foundation for trainers to develop more effective training programs, potentially enhancing athlete sprint performance based on these findings.

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