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Research Article

Running Spatiotemporal Parameters are Associated with Standing Long Jump Distance and BMI in Children aged 3-10 Years

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HIGHLIGHTS

- Longer SLJ distance is associated with higher running speed in children.
- Older and male children performed better on the SLJ test than their peers.
- Increased BMI reduced velocity, cadence, and swing phase during running.
- Overweight children presented lower velocity and swing phase during running.

ABBREVIATIONS

BMI	Body mass index
ES	Effect size
FR	Running at a fast velocity
GLM	Generalized linear model
LL	Leg length
SLJ	Standing long jump
SSR	Running at a self-selected velocity
SSW	Walking at a self-selected velocity

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BACKGROUND: Standing long jump (SLJ) distance may be related to running velocity in children aged 4-5. However, this hypothesis still requires further investigation and should be tested in a wider age range of the child population. Moreover, increased body mass index (BMI) may affect spatiotemporal parameters, and its impact seems to change with age and different activities such as running, requiring further study.
AIM: We aimed to investigate the associations between running velocity and the SLJ distance in children aged 3-10 years. We also described sex-specific normative values for SLJ. Further, the association between BMI and running and walking spatiotemporal parameters was presented.
METHOD: This study included 181 children aged 3–10 years. SLJ was measured through standard procedures. We assessed running through the absolute and normalized velocities, cadence, step length, cycle time, and duration of the swing and stance phases using the GAITRite walkway. Participants completed three valid trials for each condition: fast running, self-selected running, and self-selected walking.
RESULTS: The SLJ distance was associated with higher running velocity. Overweight children presented lower absolute velocity and longer stance phases than normal-weight children.
CONCLUSION: Higher running velocities were associated with greater SLJ distances in children, likely due to greater leg muscle strength, growth, motor development, and the correspondent biomechanical determinant between jumping and running motor skills. Increased BMI influenced spatiotemporal parameters—even in non-obese children— likely due to muscle weakness and impaired dynamic balance and stabilization, with a potentially greater impact during running than walking.

KEYWORDS: Biomechanics | Physical Fitness | Motor Development | Muscle Strength | Kinematic Running Analysis

INTRODUCTION

Early childhood is a critical phase for motor development, during which children acquire fundamental motor skills. As one of these skills, running is shaped by various environmental and biological factors. Typical immature running patterns usually develop around 18 months, taking 4-6 years for children to achieve maturity and up to 10 years to achieve specific running expertise [1,2]. During this process, the acquisition of other fundamental motor skills and changes in anthropometric measures can influence running spatiotemporal parameters [3,4].

Jumping is another fundamental motor skill children develop in early childhood, and researchers commonly assess it using the Standing Long Jump (SLJ), a widely used test to evaluate physical fitness in children [3,5,6]. Normative references show that age increases jump distances in children and adolescents aged 3 to 18 years [5,7]. The SLJ test is also considered an index of upper and lower-body muscular fitness in children [8], and previous studies have demonstrated an association between better performances in this test with higher stature [9,10] and better gross motor development [11]. Some findings have demonstrated an association between jump and sprint abilities in young athletes [12,13], and Bertozzi et al. [3] found that SLJ distance predicts sprinting velocity in children aged 4-5 years. Previous evidence suggests that greater muscle strength, assessed through the SLJ test, may explain the increased capacity for running at higher velocities [3,8]. However, this hypothesis requires further investigation and should be tested across a broader age range within the child population.

Regarding gait spatiotemporal parameters, previous studies have shown that obese and overweight children tend to have increased cycle time, stance phase duration, and double support while their velocity and cadence decrease [4,14–18]. However, previous evidence has grouped obese and overweight participants when investigating the influence of Body Mass Index (BMI) on gait biomechanics. Further, recent studies by Cimolin et al. [19] and Porta et al. [20] found no differences in spatiotemporal parameters between overweight and normal-weight children during walking [19,20]. In this way, we believe that the influence of BMI on running spatiotemporal parameters can still be further clarified.

Therefore, we aimed to investigate the associations between (1) running velocity and SLJ distance; and (2) BMI and the spatiotemporal parameters of self-selected and fast running and self-selected walking in children aged 3-10 years. Additionally, we presented sex-specific descriptive reference values for the SLJ distance in this population and compared spatiotemporal parameters between normal-weight and overweight children. We hypothesized that children with greater SLJ distances would also run at higher velocities than their peers. Regarding the association of spatiotemporal parameters with BMI, we believed that higher BMI would be associated with reduced velocities, cadence, and step length in addition to greater cycle time, longer stance phase, and shorter swing phase.

METHODS

This study initially evaluated 188 children aged 3–10 years recruited from local primary schools and through social media. Verbal consent was obtained from all participants, and written informed consent was obtained from their parents. All parents completed a questionnaire to verify their children's eligibility. The exclusion criteria were preterm birth, musculoskeletal and neurological disorders, and obesity. After applying the exclusion criteria, 181 children (97 females) were included in the study. The experimental protocol was approved by the Research Ethics Committee of the University of Brasilia (Protocol number: 5.978.773).

In this cross-sectional study, we adopted standard procedures to measure height and weight. Height was measured with 0.1 cm accuracy using a measuring tape fixed to the wall, and weight was collected using a mechanical balance accurate to 0.01Kg. For normalization purposes, leg length was obtained using the *total true shortening method*, which consists of positioning a measuring tape from the anterior superior iliac spine to the medial malleolus on the same side [21–23]. Body mass index was calculated as the body mass divided by height squared (kg/m²). The cut-off percentile points established by Cole et al. [24] were used to identify children as having normal weight, overweight, or obesity. Starting at 5 years of age, twenty children were identified as being overweight and 7 as obese. Obese children were excluded from all the analyses [24,25].

Then, participants were asked to stand with both feet touching a marked line and push vigorously to perform a standing long jump in which they should land on both feet as far as possible. Subjects were allowed to swing their arms before the jump. Distance was measured in centimeters from the take-off line to the point where the back of the heel nearest to the take-off line lands. The participants performed the test three times with at least a 1-minute interval between trials, and we computed the highest performance. We did not consider jumps if the children fell or did not take off or land on both feet; in this case, we allowed them another trial [7,8,26].

The spatiotemporal parameters were measured using the GAITRite® electronic walkway (CIR Systems), which has been previously validated and used to measure the spatiotemporal parameters of walking and running in children [27–30]. The GAITRite® includes eight sensor blocks on a mat with an active area of 61 cm (24 inches) width and 488 cm (192 inches) length, totaling 18.432 sensors. We positioned the equipment on an even floor surface with a 2 m acceleration/deceleration space on each end of the mat. Participants received standardized instructions to begin from the start line and move to the finish line, walking at a self-selected velocity (SSW) or running at a self-selected (SSR) or a fast (FR) velocity. The test conditions were respectively described as: "your comfortable/typical walking/running velocity," and "your fastest running velocity" with no enforcement for it (i. e., by a metronome or timer) as this may cause modifications to the gait pattern [31,32].

All the children were barefoot and completed three valid trials for each condition. Trials had to have at least four-foot contacts to be considered valid. Mean values for the three valid trials were calculated and used for subsequent analyses. Notably, taller children or those with longer step lengths sometimes placed only three feet in contact with the walkway, requiring more trials to achieve the required number of valid trials. Furthermore, we excluded partial footfalls from the analysis. All measures were calculated using pre-programmed definitions by the GAITRite® software. The parameters collected were absolute velocity (cm/s), normalized velocity—obtained after dividing the velocity by the average leg length and expressed as leg length per second (LL/s)— [21,32–34], cadence (steps/min), step length (cm), normalized step length (cm/LL) cycle time (s), swing phase duration (% gait cycle), and stance phase duration (% gait cycle). To compare spatiotemporal parameters between normal-weight and overweight children during running and walking 20 normal-weight children were matched by age, sex, and height with the overweight group. All experimental procedures were performed on the same day, with an average duration of 30 minutes per participant. Data collection took place in local primary schools or the university according to the participants' convenience.

Statistic procedures

The descriptive statistics of the study participants were presented as means and standard deviations. The Shapiro-Wilk test was performed to investigate data distribution, and to verify the homogeneity of variances, Levene's test was used.

Association between running velocity and the standing long jump

The generalized linear model (GLM) [35] for continuous dependent variables - with the Holm post-hoc for multiple comparisons - was used to verify the association between the SLJ distance and the absolute and normalized velocities of running at self-selected and fast conditions. We adjusted the model for confounding variables: age, sex, and BMI. Descriptive data for the SLJ distance was presented as the 5^{th}, 25^{th}, 50^{th}, 75^{th}, and 95^{th} percentiles.

Association between spatiotemporal parameters and BMI

The generalized linear model (GLM) [35] for continuous dependent variables - with the Holm *post-hoc* for multiple comparisons – was also used to verify the association between BMI and the spatiotemporal parameters at each gait condition. We adjusted the model for confounding variables: age and sex.

The student's *t-test* was used to compare normal-weight and overweight participants when data presented a normal distribution. For data that did not present a normal distribution, a nonparametric equivalent (Mann-Whitney) was performed. Effect sizes (ES) for this comparison were calculated according to Cohen's d specifications (0.20 to 0.50 – small effect; 0.50 to 0.80 – medium effect; > 0.80 – large effect) [36]. Data were expressed as means and standard deviations, and median and quartiles as appropriate.

For all GLM analyses, we presented descriptive data using the mean and 95% confidence interval. We adopted a significance level of $p < .05$ for all analyses. Statistical analyses were performed using R Software (version 4.1), a language and environment for statistical computing.

RESULTS

Older children were taller and presented greater body mass, BMI, and leg length than their younger counterparts (Table 1; $p < .05$). There were no between-group differences in anthropometric measures according to sex.

Table 1. Characteristics of children age groups.

Age (Years)	Gender (Females)	Height (cm)	Body Mass (kg)	BMI (kg/m²)	Leg Length (cm)
3 (n = 11)	5 (45.5%)	94.5 ± 3.6	14.1 ± 1.7	15.7 ± 1.2	39.1 ± 3.2
4 (n = 21)	10 (47.6%)	109 ± 9.4	16.8 ± 3.2	14.1 ± 1.9	46.0 ± 4.4
5 (n = 38)	24 (63.2%)	112 ± 4.4	18.7 ± 3.1	14.8 ± 1.9	49.6 ± 3.3
6 (n = 23)	14 (60.9%)	117 ± 6.4	20.5 ± 3.1	14.9 ± 1.6	54.1 ± 4.1
7 (n = 19)	9 (47.4%)	124 ± 5.0	23.6 ± 4.8	15.2 ± 2.3	57.0 ± 4.8
8 (n = 21)	11 (52.4%)	132 ± 6.4	27.6 ± 5.2	15.7 ± 2.1	62.9 ± 4.1
9 (n = 23)	13 (56.5%)	139 ± 6.2	32.0 ± 6.9	16.4 ± 2.6	67.0 ± 3.4
10 (n = 25)	11 (44%)	141 ± 6.8	33.6 ± 7.7	16.6 ± 2.7	68.1 ± 4.6

Data are presented as mean ± standard deviation;

The SLJ distance was significantly associated with running velocity, with the increases in the SLJ distance resulting in greater absolute (SSR: $R^2 = 0.11$, $p <.001$; FR: $R^2 = 0.44$, $p < .001$) and normalized (SSR: $R^2 = 0.38$, $p =.002$; FR: $R^2 = 0.32$, $p <.001$) velocities at both running conditions (Table 2). The descriptive reference values for the SLJ distance (Table 3) indicated that older children tended to reach greater distances than younger ones. Further, male children tended to present greater distances for the SLJ test.

BMI values were associated with running and walking spatiotemporal parameters (Table 4). At the fast-running condition absolute velocity ($\beta = -3.9$; $p = .022$), normalized velocity ($\beta = -0.1$; $p < .001$), and cadence ($\beta = -3.0$; $p = .001$) were reduced with higher BMI. Increasing BMI also reduced the swing phase (SSR: $\beta = -0.6$, $p = .003$; SSW: $\beta = -0.3$, $p = .045$) and increased the stance phase ($\beta = 0.6$, $p = .003$; SSW: $\beta = 0.3$, $p = .045$) at self-selected running and walking.

Table 2. Association between SLJ distance and velocity during self-selected and fast running.

SELF-SELECTED RUNNING	Estimate	R^2	95% CI		*p*
			Lower	Upper	
Absolute Velocity (m/s) SLJ (cm)	114.9	0.11	59.8	170.1	**< .001***
Normalized Velocity (LL/s) SLJ (cm)	165	0.38	62	268	**.002***
FAST RUNNING	**Estimate**	**R^2**	**95% CI**		***p***
			Lower	**Upper**	
Absolute Velocity (m/s) SLJ (cm)	125.4	0.44	85.9	164.9	**< .001***
Normalized Velocity (LL/s) SLJ (cm)	163	0.32	76	251	**< .001***

SLJ: standing long jump. Multivariate model adjusted by age, sex, and BMI.

Table 3. Descriptive data of SLJ distance in female and male children aged 3-10 years.

	Age	Sex	N	Percentile				
				5th	25th	50th	75th	95th
SLJ (cm)	3	F	2	46.1	50.3	55.5	60.8	64.9
		M	5	43.2	56	61	64	64
	4	F	10	44.5	57.3	67	78.2	89.9
		M	11	58.5	65.5	77	99.5	111
	5	F	24	74.2	82.7	95	108	114
		M	14	75.6	85	94.5	108	125
	6	F	14	66.9	94.8	104	110	134
		M	9	84.6	109	112	123	140
	7	F	9	96	108	109	123	132
		M	10	105	113	118	127	133
	8	F	11	94	106	118	122	127
		M	10	104	115	122	131	140
	9	F	13	96.2	115	121	129	140
		M	10	112	130	134	155	162
	10	F	11	99	117	125	139	144
		M	14	122	128	147	161	182

SLJ: standing long jump; F: females; M: males.

Table 4. Association between BMI and the spatiotemporal parameters during running and walking.

	FAST RUNNING			SELF-SELECTED RUNNING			SELF-SELECTED WALKING		
Effect	**Estimate**	**95% CI**	***p***	**Estimate**	**95% CI**	***p***	**Estimate**	**95% CI**	***p***
Absolute Velocity (cm/s)									
BMI	-3.9	-7.2--0.6	**.022***	-1.6	-5.9-2.6	.458	0.2	-1.2-1.5	.826
Normalized Velocity (LL/s)									
BMI	-0.1	-0.2--0.1	**.001***	-0.1	-0.1-0.02	.155	-0.01	-0.03—0.02	.714
Cadence (steps/min)									
BMI	-3.0	-4.9--1.2	**.001***	-0.7	-2.7-1.3	.481	-0.3	-1.3-0.7	.590
Step Length (cm)									
BMI	0.4	-0.3-1.1	.255	-0.2	-1.0-0.7	.672	0.3	-0.1-0.6	.182
Normalized Step Length (cm/LL)									
BMI	-0.01	-0.02-0.01	.355	-0.01	-0.03-0.00	.110	0.00	-0.01-0.01	.702
Cycle time (s)									
BMI	0.01	-0.00-0.03	.087	0.01	-0.01-0.02	.503	0.01	-0.00-0.03	.069
Swing (% gait cycle)									
BMI	-0.1	-0.5-0.4	.832	-0.6	-1.0--0.2	**.003***	-0.3	-0.6--0.01	**.045***
Stance (% gait cycle)									
BMI	0.04	-0.4-0.5	.838	0.6	0.2-1.1	**.003***	0.3	0.01-0.6	**.045***

Multivariate model adjusted by age and sex.

Normal-weight and overweight groups only presented differences in body mass and BMI, as expected (Table 5). Moreover, comparisons between normal-weight and overweight children (Table 6) showed lower absolute velocity for the overweight group during the fast-running condition (p = 0.033; ES = 0.70). During self-selected running the overweight children were presented with longer stance phase duration (p = 0.018; ES= 0.44), and shorter swing phase duration (p = 0.018; ES= 0.44).

Table 5. Characteristics of normal-weight and overweight children.

	Normal-Weight (n=20)	**Overweight (n=20)**	***p***
Gender (females)	14 (70%)	14 (70%)	-
Age (years)	7.7 ± 1.8	7.7 ± 1.8	1.000
Height (cm)	131. 9 ± 11.6	132.5 ± 13.4	0.87
Body mass (kg)	27.5 ± 6.1	35.2 ± 9.2	**0.004***
Body Mass Index (kg/m2)	15.7 ± 1.8	19.6 ± 1.5	**<0.001***
Leg Length (cm)	62.8 ± 7.1	63.4 ± 8.2	0.807

Data are presented as mean ± standard deviation; *p<0.05 (Students' *t* Test).

Table 6. Comparisons of spatiotemporal parameters between these normal-weight and overweight groups.

		Mean (±SD)	Median (min - max)	Mean (±SD)	Median (min - max)	*p*	**ES**
Absolute Velocity (cm/s)	Fast Running	417.8 ± 51.6	421.3 (388.3-439.3)	386.3 ± 36.8	386.2 (364.3-420.1)	**.033***	0.7
	Self-selected Running	340.7 ± 79.4	342.4 (281.3-370.9)	321.5 ± 58.5	317.4 (273.7-370.5)	0.39	0.27
	Self-selected Walking	112.2 ± 20.5	114.9 (93.9-133.9)	108.1 ± 15.5	110.9 (93.8-116.8)	0.302	0.23
Normalized Velocity (LL/s)	Fast Running	6.3 ± 1.7	6.67 (5.9-7.2)	6.2 ± 1.0	6.2 (5.4-6.6)	0.379▲	0.17
	Self-selected Running	5.4 ± 1.9	5.5 (4.2-6.5)	5.2 ± 1.3	5.6 (3.9-6.4)	0.688	0.13
	Self-selected Walking	1.7 ± 0.5	1.8 (1.6-1.9)	1.7 ± 0.3	1.8 (1.5-1.9)	0.661	0.02
Cadence (steps/min)	Fast Running	239.6 ± 28.3	237.5 (221.5-253.8)	223.7 ± 26.5	228.9 (207.7-236.5)	0.073	0.58
	Self-selected Running	217.2 ± 48.6	217.5 (181.3-255.9)	215.7 ± 34.4	228.2 (189.0-234.8)	0.915	0.03
	Self-selected Walking	124.4 ± 14.5	121.9 (118.8-131.6)	120.8 ± 13.7	118.9 (110.6-128.9)	0.525	0.25
Step Length (cm)	Fast Running	103.7 ± 14.7	108.5 (93.6-112.7)	104.7 ± 11.4	106.7 (99.5-109.8)	0.818	-0.07
	Self-selected Running	94.2 ± 13.4	93.0 (84.9-102.3)	90.2 ± 12.4	90.4 (82.3-97.1)	0.334	0.31
	Self-selected Walking	54.2 ± 9.2	53.2 (48.3-58.8)	53.9 ± 5.6	54.1 (51.1-56.8)	0.803	0.03
Normalized Step Length (cm/LL)	Fast Running	1.7 ± 0.2	1.6 (1.5-1.8)	1.6 ± 0.1	1.6 (1.6-1.7)	0.948	-0.02

	Self-selected Running	1.5 ± 0.2	1.5 (1.4-1.6)	1.4 ± 0.2	1.5 (1.3-1.6)	0.305	0.33
	Self-selected Walking	0.9 ± 0.1	0.9 (0.8-0.9)	0.9 ± 0.1	0.8 (0.7-0.9)	0.881	0.08
Cycle Time (s)	Fast Running	0.5 ± 0.1	0.5 (0.4-0.5)	0.6 ± 0.2	0.5 (0.5-0.6)	0.167▲	0.26
	Self-selected Running	0.7 ± 0.3	0.6 (0.5-0.6)	0.6 ± 0.2	0.5 (0.5-0.3)	0.745▲	0.06
	Self-selected Walking	1.1 ± 0.4	1.0 (0.9-1.0)	1.2 ± 0.2	1.1 (1.0-1.2)	0.398▲	0.43
Swing (% Gait Cycle)	Fast Running	66.1 ± 6.5	67.2 (63.9-70.2)	65.5 ± 5.3	66.3 (64.8-67.3)	0.495▲	0.13
	Self-selected Running	65.3 ± 7.2	67.1 (63.9-69.0)	62.3 ± 5.3	62.84 (60.2-64.8)	**.018#**	0.44
	Self-selected Walking	37.8 ± 4.6	38.6 (36.7-41.4)	36.9 ± 3.8	37.1 (33.4-40.6)	0.145	0.22
Stance (% Gait Cycle)	Fast Running	33.9 ± 6.5	32.8 (29.8-36.1)	34.5 ± 5.4	33.8 (32.7-35.2)	0.495▲	0.13
	Self-selected Running	34.7 ± 7.2	32.95 (31-36.1)	37.7 ± 5.3	37.1 (35.2-39.8)	**.018#**	0.44
	Self-selected Walking	62.2 ± 4.6	61.4 (58.6-63.2)	63.1 ± 3.8	62.9 (59.1-66.6)	0.144	-0.22

Data are presented as mean ± standard deviation and median and quartiles (Q1 and Q3); *p<0.05 (Students' *t* Test); #p<0.05 (Mann-Whitney); ▲ indication of nonparametric parameters that did not present significant *p* values.

DISCUSSION

This study investigated the associations between (1) running velocity and the SLJ distance; and (2) BMI and the spatiotemporal parameters of running and walking in children aged 3-10 years. Further, we described the SLJ distance values of male and female children and the comparisons for the spatiotemporal parameters between normal-weight and overweight children.

Previous research by Bertozzi et al. 3 found longer SLJ distances to predict higher 10-meter sprinting velocity in 4-5-year-old children. In the present study, children ran approximately 10m, considering the mat length and the acceleration/deceleration spaces at each end, making it possible to compare data. Our results follow these findings: children who jumped longer distances also presented higher absolute and normalized velocities in fast-running conditions. Further, our findings improve the understanding of this association showing that SLJ distance was also related to higher absolute and normalized velocities during self-selected running. According to Castro-Piñero et al. [8], larger SLJ distances are directly related to greater upper and lower body muscular strength, which may explain why a better performance in the SLJ test implicates greater muscle strength and, consequently, an improved capacity to increase velocity during running [3,37]. Furthermore, these findings reinforce that there is an important and complex biomechanical association between these two fundamental motor skills.

Greater SLJ distances for male and older children have been reported before [5,7,9] and were also seen in this study. Regarding sex differences, authors reported boys aged 3 to 18 to present longer distances for the SLJ test and associated these results with possible differences in moderate-to-vigorous physical activity and neuromuscular maturation among preschool females and males. Aging during childhood can be associated with greater height and weight in addition to more mature motor development, and according to previous studies, these factors seem to play an important role in SLJ performance [10,11]. Hraski et al. [10] assessed the relationship between morphological characteristics and kinematic parameters of the SLJ and found that children who were taller and had longer arms and legs achieved longer distances. Further, Wang et al. [11] studied the relationship between jumping performance and gross motor development and showed that children with better jumping performance also had better gross motor development. In this way, we inferred that older children in this study may have reached longer distances in the SLJ than their younger counterparts due to their greater height and weight, in addition to an expected more advanced motor development.

The running cycle phases at the self-selected running and self-selected walking conditions were associated with BMI, with a reduction for the swing phase and a longer stance phase when BMI increased. These results could be expected since they are commonly reported due to increased BMI [4,14–17,25]. Evidence suggests that this increase in stance phase duration may be due to muscle weakness and decreased dynamic balance and stability, since it may help these children better to control the impact of a single leg landing, while also attempting to regain stability before propulsion to the next limb [4,38,39]. According to Nantel et al. [40], obese children transfer mechanical energy less efficiently from the stance phase to the swing phase. In this respect, the influence of obesity on the phases of gait might be related not only to the optimization of energy consumption but also to a strategy of balance stabilization and the prevention of falls [25].

However, comparisons between groups with different BMI classifications are often conducted by grouping overweight and obese children and recent previous research has shown that overweight and normal-weight children have similar spatiotemporal patterns during walking [19,20]. In this way, our results help clarify the understanding of the effect of BMI on running spatiotemporal parameters since overweight children presented lower absolute velocity during the fast-running condition and a longer stance phase combined with a shorter swing phase during self-selected running. Thus, our results indicate that the increment in BMI, even without an obesity classification, could also affect running spatiotemporal parameters.

Our main limitation is that some older or taller participants would only make three-foot contact when running in high-speed conditions, given the space restriction of the equipment. This condition resulted in more trials by the children to achieve the number of valid trials required or even the exclusion of participants. Additionally, given that the data collection occurred in different places, some children's performance may have been affected. When tests were conducted at local schools, children may have been more comfortable in the familiar environment but could also be influenced by their colleagues. Further, the laboratory environment and unfamiliar people could intimidate some participants. The assessment of the maturational stage of the study participants could have contributed to an even deeper understanding of the results found, justifying and discussing the behavior of the studied parameters based on the process of child growth and maturational level. For this reason, we believe that the lack of a maturational assessment is another limitation of our study, which can be considered in future investigations.

CONCLUSION

Higher running velocities were associated with greater SLJ distances in children, likely due to greater leg muscle strength, growth, motor development, and the correspondent biomechanical determinant between jumping and running motor skills. The spatiotemporal parameters of running showed significant associations with BMI, as expected. Overweight children displayed lower absolute velocity and longer stance phase than normal-weight children, suggesting that higher body mass -even in non-obese children- may alter spatiotemporal parameters during running.

Our findings suggest that the complex and nonlinear system involved in running and jumping development may share similar biomechanical and motor control constraints (muscular strength) that could impact atypical development in both motor skills. Our results also indicate that morphological constraints and reduced physical capacity (e.g., muscle strength) in overweight children may also lead to atypical development in both skills. These insights emphasize the importance of body composition and muscular strength in locomotor skill development, highlighting a critical area for targeted intervention in children.

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