Sports Training

Running performance of non-professional female runners from different Brazilian states: the role of environmental characteristics

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Abstract - Aims: (*i*) to compare the running performance of non-professional female runners from different Brazilian states; (*ii*) to estimate the relationship between environmental state-related variables and running performance; and (*iii*) to analyze the mediation role of training commitment in the relationship between the environment and running performance. **Methods:** A total of 418 non-professional female runners were sampled from the five Brazilian regions. An online questionnaire was used for data collection and included self-reported information about age, body weight, body height, place of residence, training volume, and running pace. Environmental characteristics were based on the Census 2010 and included percentages of public illumination, asphalt, sidewalks, and green areas for state capital cities. Linear regression, Pearson correlation, and mediation analysis were performed using SPSS 26, at a 95% confidence interval. **Results:** The fastest women were from the Rio Grande do Sul. Significant differences were observed between Rio Grande do Sul and Rio Grande do Norte (β= 45.79; 95%CI = 16.86 – 74.73), Distrito Federal (β = 34.55; 95%CI = 1.87 −67.24), and Sergipe (β = 35.34; 95%CI = 14.09−56.60). A negative relationship was observed between running pace with green areas (r = −0.206; 95%CI = −0.305 – −0.110) and training volume (r = −0.343; 95%CI = −0.427−0.167). Training volume explained 23% of the relationship between the percentage of green areas and running performance. **Conclusion:** The fastest runners were from the Rio Grande do Sul. Higher percentages of green areas can favor performance, which is partly mediated by increased training volume.

Keywords: female athletes, endurance, environment, performance, runners.

Introduction

An increase in the number of runners and running events have been observed in recent years[1], leading it to be cited as one of the main trends for physical activity around the world[2]. Since running training and competition are mainly performed in outdoor environments (i.e., streets, parks, tracks), runners are exposed to a plethora of constraints that can impair their training commitment and performance - that include, but are not limited to, natural and physical environment[3].

The ecological theory highlights that the subject-environment interplay is associated with the adoption of different behaviors[4]. In the context of sports science, this means that the interaction between physical (e.g., city design, geography) and sociocultural characteristics (e.g., sports policy, cultural background, economic and demographic characteristics) can impair the adoption of movement behaviors in different contexts[5, 6]. In this sense, some environments seem to be friendlier to physical activity practices and running training than others, since these environments present characteristics that impact the runner's commitment to the practice, such as favorable and safe street designs, public illumination, and car traffic[3,7].

Notwithstanding that environmental characteristic play a relevant role in the adoption of physical activity habits in both sexes, women generally tend to be more affected[7]. Previous studies showed a large number of barriers to physical activity practice in women[8,9]. Specifically, in the running context, a report showed that 45.8% of female runners have experienced harassment during

their training, with approximately 80% of them having changed their training habits and routes[10]. In addition, the absence of available places for running practice and the security perception (e.g., violence, fear of crime) can impair training commitment. Therefore, the relationship between the physical environment and running commitment seems to be established[3,11].

Taking into account the differences between Brazilian states regarding environmental and socioeconomic characteristics, studies were developed to investigate the influence of these differences on the adoption of movement behaviors[12], sports practice[13], sports performance[14], and support for the development of sports programs[15]. These studies were often developed to understand factors associated with physical activity, and results highlighted the role of sex and place of residence in the expression of the mentioned behavior[16-18]. However, few studies have been carried out aiming to understand the relationship between environmental characteristics and female runners' performance. Since the number of female runners has increased more than male runners, it seems relevant to better understand this relationship in this group. Thus, the purposes of this study were to (i) compare the running performance of non-professional female runners from different Brazilian states; (ii) estimate the relationship between environmental state-related variables and running performance; and (iii) analyze the mediation role of the training commitment (e.g., training volume) in the relationship between environment and running performance.

Methods

Ethical approval

The study was performed in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of the Federal University of Sergipe (protocol nº 3558630).

Design and sample

The sample came from the InTrack project, a cross-sectional research project which was developed in Brazil from 2019 to 2020[19]. The eligibility criteria were answering the online questionnaire and self-classification as a runner. For the present study, male runners, those aged below 18 years, and athletes from the states where the total sample was under 10 subjects (Acre, Amazonas, Maranhão, Ceará, Matos Grosso do Sul, Pará, Roraima, and Santa Catarina) were excluded due to the low representativeness of the state[20]. Thus, the sample comprised 418 non-professional runners, from the five Brazilian regions (Southeast = 36.4%; Northeast = 34.7%; North = 6.5%; South = 13.4%; Midwest = 9.1%). Participants agreed to participate in the study and were assured of the confidentiality and anonymity of the data. Moreover, participants were informed about the nature and purposes of the study and gave their written informed consent before completing the questionnaire.

Data collection procedures

Subject's information

Information was obtained through the online questionnaire "Profile characterization and associated factors for runner's performance"[21]. Through the use of an online platform (Google forms), the questionnaire was distributed via social media to runners interested in participating in the research. The questionnaire was available to answer between November 2019 and March 2020. This strategy was chosen to cover all Brazilian states, but there was no expectation to obtain a representative sample of the population. The questionnaire collected information regarding: a) *Runner's identification:* age, body weight (kg), and body height (m), which were self-reported. Body mass index (BMI) was calculated through the formula: weight (kg)/height $(m)^2$; b) *Place of residence:* participants provided information regarding their state of residence and also if they live in the state capital (yes or no); c) *Training volume/week:* information regarding the average kilometers covered during a typical week of training sessions; and d) *Running pace:* the time taken to cover one kilometer, over the distance of preference. This variable was considered as the outcome variable, in seconds per kilometer.

Environmental characteristics

Information regarding the environmental characteristics was obtained from the Brazilian Institute of Geography and Statistics, based on the Census 2010 - Urban household characteristics and their surroundings[22]. For the present study, the following information was used: a) *Public illumination:* highlights the existence of, at least, one public light point near the residence; b) *Asphalt:* the existence of a paved surface in the public venues/streets; c) *Sidewalk:* the existence of a paved sidewalk, for pedestrians; and d) *Green areas*: indicates the existence of trees across the sidewalks or even tree lines that split lanes. The total percentages of these characteristics were computed based on the total domiciles for which the characteristics were reported and the total population [(number of inhabitants for which the characteristics are presented - total inhabitants) * 100].

Statistical analysis

Descriptive statistics are presented as mean, standard deviation (SD), and relative frequencies (%). Data normality distribution was tested through the Kolmogorov-Smirnov test, by states. To identify differences in performance among female runners, states were dummy coded, and the Rio Grande do Sul was the state of reference since

runners from this state presented the best mean performance (differences for each state from the Rio Grande do Sul were graphically presented). An age-adjusted regression model was built, with all the states included, aiming to estimate differences in the performances in each state from the Rio Grande do Sul.

Pearson correlation was performed to estimate the relationship between environmental characteristics (public illumination; asphalt; sidewalk; and green areas) and running performance. The magnitude of the correlation was determined by the scale proposed by Batterham and Hopkins[23], as following: $r < 0.1$, trivial; $r = 0.1$ to < 0.3, small; $r = 0.3$ to < 0.5, moderate; $r = 0.5$ to < 0.7, strong; $r = 0.7$ to < 0.9, very strong; $r = 0.9$ to < 1.0 almost perfect; and $r = 1.0$, perfect. Bootstrap results were performed based on 1000 bootstrap samples.

Following the Pearson correlation results, a mediation analysis was performed. Models were computed considering the training volume (km/week) as a mediating variable; the percentage of green areas was used as the independent variable, and the running pace (s/km) was considered as the dependent variable. Total, direct, and indirect effects of the independent variable on the dependent variable were presented[24]. The Mediation proportion was computed based on the ratio between direct effect and total effect, after which the Mediating effect was calculated: 1 - (Mediation proportion). Statistical Package for Social Sciences (SPSS), version 26®, and SPSS AMOS were used for all statistical analyses, adopting a significance level of $p < 0.05$.

Result

Table 1 presents the descriptive characteristics of the participants. The participant's age varied between 33.7 y (Tocantins) and 44.3 y (Bahia). The mean BMI was below 25 kg/m^2 in all states. The lowest and highest training volumes were observed for Piauí (17.5 km/week) and Rio de Janeiro (36.3 km/week), respectively, while the running pace varied between 323.5 s/km (the Rio Grande do Sul) and 389.1 s/km (Rio Grande do Norte). In most states, participants were predominantly from capital cities.

The environmental characteristics of the states are presented in Table 2. Most of the states presented high percentages regarding the presence of the investigated environmental indicators. The lowest and highest values for each characteristic were: public illumination (Amapá: 89.3% vs Espírito Santo and Goiás: 99.4%), asphalt (Amapá: 59.8% vs Espírito Santo: 98.9%), sidewalk (Amapá: 32.5% vs Minas Gerais: 92.9%), and green areas (Distrito Federal: 34.6% vs Goiás: 88.9%).

The differences in running pace from each state in relation to Rio Grande do Sul (Δ) are shown in Figure 1. Significant differences were observed for Rio Grande do Norte (β = 45.79; 95%CI = 16.86-74.73), Distrito Federal (β = 34.55; 95%CI = 1.87-67.24), and Sergipe (β = 35.34; 95%CI = 14.09-56.60).

The relationship between the running pace and the environmental characteristics is presented in Table 3. Only green areas and training volume (km/week) showed a significant and inverse correlation with running pace

Table 1 - Descriptive information for athletes, considering the state of residence.

	Age (years)	BMI (kg/m^2)	Volume (km/week)	Running pace (s/km)	Living in state capital city (Yes)
State			**Mean (SD)**		**n (%)**
Alagoas (n = 13)	38.9 (6.1)	24.6 (3.6)	20.3 (11.5)	358.6 (45.1)	13 (100%)
Amapá (n = 14)	37.9 (9.8)	23.9 (2.6)	21.0 (12.8)	354.6 (56.3)	11 (78.5%)
Bahia (n = 13)	44.3 (6.5)	24.4 (2.7)	24.8 (8.8)	372.3 (51.5)	3 (23.0%)
Distrito Federal (n = 14)	37.5 (5.9)	21.7 (1.4)	25.4 (9.9)	372.1 (36.0)	14 (100%)
Espírito Santo (n = 20)	34.4 (7.7)	23.7 (2.4)	31.6 (14.8)	348.2 (34.7)	6 (30%)
Goiás (n = 12)	40.6 (3.0)	24.1 (3.3)	25.7 (13.6)	360.4 (56.0)	8 (66.6%)
Mato Grosso (n = 12)	38.2 (8.5)	23.6 (2.0)	26.5 (21.1)	371.6 (61.9)	9 (75.0%)
Minas Gerais (n = 42)	38.6 (7.9)	23.0 (3.2)	31.1 (17.9)	347.4 (51.3)	16 (38.0%)
Paraná (n = 37)	39.7 (8.0)	23.9 (2.7)	32.4 (16.5)	337.2 (44.2)	24 (64.8%)
Pernambuco (n = 16)	37.7 (8.2)	22.5 (2.8)	26.6 (10.3)	334.1 (43.1)	12 (75.0%)
Piauí (n = 13)	37.7 (11.2)	23.4 (2.5)	17.4 (7.8)	365.6 (47.5)	13 (100%)
Rio de Janeiro (n = 24)	39.4 (10.1)	24.0 (2.8)	36.3 (29.2)	355.6 (57.0)	14 (58.3%)
Rio Grande do Norte (n = 18)	41.5 (8.4)	24.1 (2.8)	24.7 (17.1)	389.1 (42.3)	16 (88.8%)
Rio Grande do Sul (n = 19)	35.2 (9.3)	22.4 (2.96)	27.6 (19.6)	323.5 (44.0)	6 (31.5%)
São Paulo (n = 66)	38.4 (8.0)	23.8 (3.0)	30.5 (17.6)	364.7 (44.9)	30 (45.4%)
Sergipe (n = 64)	36.3 (8.3)	23.2 (2.7)	20.5 (9.9)	373.8 (39.5)	39 (60.6%)
Tocantins (n = 10)	33.7 (15.2)	22.7 (3.4)	30.0 (9.6)	344.8 (72.9)	7 (70.0%)

(r = −0.206; 95%CI = −0.305 − −0.110; r = −0.343; 95% CI = −0.427−0.167, respectively). That is, an increment in the percentage of green areas in the state capital city, as well as higher training volume, indicate a decrease in the time to cover one kilometer. Significant, positive, and weak relationships were observed between environmental characteristics (i.e., asphalt and green areas) and training

Table 2 - Descriptive information present in % for environmental characteristics.

State	Public illumination	Asphalt	Sidewalk	Green areas
Alagoas	95.93	64.04	70.42	56.49
Amapá	89.31	59.76	32.54	65.13
Bahia	95.18	88.49	61.27	38.35
Distrito Federal	97.48	91.93	76.18	34.63
Espírito Santo	99.37	98.89	81.55	62.63
Goiás	99.37	97.62	87.54	88.85
Mato Grosso	93.80	66.52	61.99	38.59
Minas Gerais	98.50	97.60	92.89	81.39
Paraná	95.71	93.46	63.93	75.11
Pernambuco	96.53	79.75	73.04	58.85
Piauí	95.21	85.83	72.05	72.49
Rio de Janeiro	92.97	90.51	84.33	68.29
Rio Grande do Norte	96.82	81.43	72.23	44.56
Rio Grande do Sul	92.40	85.16	72.23	79.50
São Paulo	96.37	95.82	91.56	73.06
Sergipe	97.29	87.94	87.60	56.45
Tocantins	98.02	82.16	55.67	79.56

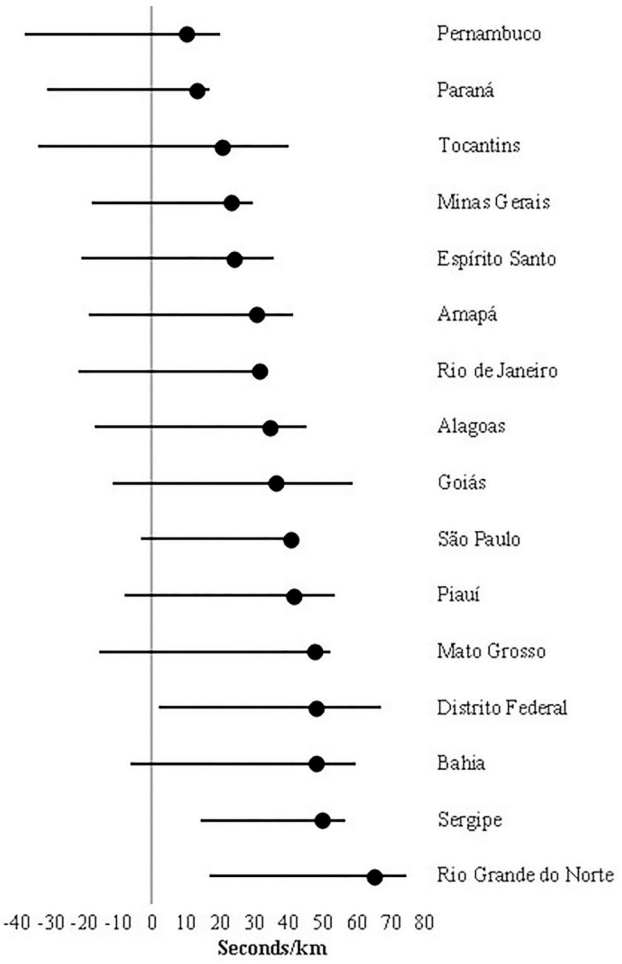

Figure 1 - Mean differences (95% confidence interval) in running pace from each state in comparison to the Rio Grande do Sul.

Table 3 - Pearson correlation between running pace, training volume, and environmental characteristics.

		Running pace	Training volume	Public illumination	Asphalt	Sidewalk	Green areas
Running pace		1	−0.343**	0.064	−0.046	0.033	−0.206**
	LL95%	1	−0.427	−0.046	−0.155	−0.075	−0.305
	UP95%	1	−0.256	0.167	0.058	0.133	−0.110
Training volume		−0.343**	1	0.007	0.163**	0.072	0.140**
	LL95%	−0.427	1	−0.091	0.075	−0.021	0.054
	UP95%	−0.256	1	0.118	0.255	0.160	0.225
Public illumination		0.064	0.007	1	0.603**	0.576**	0.068
	LL95%	−0.046	−0.091	1	0.520	0.479	−0.014
	UP95%	0.167	0.118	1	0.677	0.660	0.151
Asphalt		−0.046	0.163**	0.603**	1	0.671**	0.437**
	LL95%	−0.155	0.075	0.520	1	0.598	0.362
	UP95%	0.058	0.255	0.677	1	0.743	0.507
Sidewalk		0.033	0.072	0.576**	0.671**	1	0.274**
	LL95%	−0.075	−0.021	0.479	0.598	1	0.199
	UP95%	0.133	0.160	0.660	0.743	1	0.350

(*continued*)

Table 3 - continued

		Running pace	Training volume	Public illumination	Asphalt	Sidewalk	Green areas
Green areas		−0.206**	0.140**	0.068	0.437**	0.274**	1
	LL95%	−0.305	0.054	−0.014	0.362	0.199	1
	UP95%	−0.110	0.225	0.151	0.507	0.350	1

Note. Running pace (s/km); Training volume (km/week); ** $p < 0.001$; LL95% (Lower); UP95% (Upper).

volume. Additionally, significant relationships were found among the environmental characteristics.

The results of the mediation analysis are presented in Table 4. The total effect indicates an improvement in running pace with increases in the green space. For the indirect effect, the results show that green area differences can explain ≈15 s of the running pace, considering the increase in training volume. For the direct effect, no significant associations were found (β = −0.56; 95%CI = −0.88-0.24). The mediation effect indicates that training volume/week explains 23% of the relationship between the percentage of green areas and running performance.

Discussion

This study aimed (i) to compare the running performance of non-professional female runners from different Brazilian states; (ii) to estimate the relationship between environmental state-related variables and running performance; and (iii) to analyze the mediation role of training commitment in the relationship between the environment and running performance. Results showed that (i) women from the Rio Grande do Sul state presented the best mean performance, with significant differences from Distrito Federal, Sergipe, and Rio Grande do Norte; (ii) cities with a high proportion of green areas favored running performance in female runners; and (iii) the training volume (km/week) mediated part of the relationship between green areas and running performance.

The best running performance was observed in the Rio Grande do Sul, which is the Brazilian state with the third-highest per capita monthly average household income[25]. Considering the higher results compared to poorer states (e.g. Sergipe and Rio Grande do Norte), we could infer that income may be an important factor related to participation in running events, as shown in a previous study[26]. However, interestingly, wealthy states such as Distrito Federal also had lower running performance in comparison to Rio Grande do Sul, which indicates that environmental characteristics can have an important role in running performance.

States from the Brazilian south region are considered environmentally friendly places for physical activity, which could favor outdoor physical activity/training practices[27]. The importance of the environment for the practice of a physical activity is emphasized in the World Health Organization Global Action Plan on Physical Activity 2018-2030[28], which provides for, as one of the strategic objectives, the development of active environments, providing access to safe environments for the regular practice of physical activity. Among the actions foreseen within this objective is the strengthening of access to green and open spaces[28]. The practice of physical activities in natural environments seems to have greater effects on physical and mental well-being than physical activities practiced in indoor environments[29], which could be associated with performance. Outdoor exercise can positively influence affection and pleasure in performing physical activities; however, the body of evidence in this area is still lacking high-quality studies to explain the effects of this relationship and also the sustainability of physical activity practices[30, 31].

There is evidence that green areas in the running environment are relevant for novice runners, and access to attractive and green spaces is recommended to maintain involvement in the running practice[3], which can also contribute to improvement in performance through increases in training volume. However, environmental aspects, such as temperature, can act on biological parameters and affect running performance in elite athletes[32]. In addition, a study by Schuurman et al[33], carried out with 1228 runners, showed that runners prefer to run in light and wooded

Table 4 - Total, direct, and indirect effects of green areas on running pace, mediated by the training volume/week.

Effects	β	95%CI (Lower - Upper)
Total effect of Green areas (X) on running pace (Y)	−0.72	−1.06 - −0.38
Direct effect of Green areas (X) on running pace (Y)	−0.56	−0.88 - 0.24
Indirect effect(s) of Green areas (X) on running pace (Y)	−0.15	−0.26 - −0.06
Mediation proportion (Direct effect/total effect)	0.77	
Mediation effect (1 - Mediation proportion)	0.23	

Note. CI = confidence interval.

environments and that the main environmental concerns are animals and dangerous conditions on the roads. However, most of the evidence available is from countries with different characteristics (e.g., social, economic, cultural, and climate) compared to Brazil. Therefore, our findings expand the literature showing that in the Brazilian context, the higher proportion of green areas is related to better running performance, which is partly explained by the higher training volume. These results should be confirmed through longitudinal studies and natural experiments which can guide public policies for sports and health promotion.

This study is not without limitations. Firstly, we can highlight the temporal gap between the environmental information (2010) and runner's data (2019-2020). However, this is the most current information available about state characteristics, and although changes can occur, it is expected to stabilize environmental characteristics for 9-10 years. Furthermore, we only used one environmental variable (i.e., green areas) in the mediation analysis; however, natural and physical environments are complex systems that cannot be reduced to a unique proxy. Secondly, the data collection procedures (i.e., from an online questionnaire) and differences in sample size between states could impair the generalization of the results, especially due to the lack of information regarding eight Brazilian states. Thirdly, we suggest careful about the generalization of the information for non-capital cities, given that, for the present research, we only have considered environmental information from the capital cities of the states. However, we highlight that 60% of the sample reported living in Brazilian capital states.

However, to the best of our knowledge, this is the first study aiming to assess and analyze performance among Brazilian female runners, as well as the relationship with environmental characteristics. The majority of previous studies were interested in understanding physical activity/exercise participation, not considering running characteristics[34, 35]. Taking into account the increment in the number of women engaged in running around the country, and the influence of the physical and natural environments on running training, it is of relevance to provide information taking into account this specific group.

Conclusions

For the present research, we have found that the fastest female Brazilian runners were from Rio Grande do Sul. From the set of environmental characteristics studied, green spaces were related to running performance, with training volume mediating the relationship between green spaces and performance. Future studies should consider the perception of Brazilian runners about their environment, training commitment, and relationships with their place of training.

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