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ORIGINAL ARTICLE

Human Development Index and the frequency of nations in Athletics World Rankings

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Abstract

Introduction The influence of socioeconomic factors in the achievement of sport success is still a matter of debate. Due to the popularity and low-cost practice, analyses of the Athletics World Ranking (AWR) may provide valuable information. Therefore, we investigated the frequency of different socioeconomic status in the AWR for two events (100 m and 10 k) in three categories: Junior, Elite Professionals and Masters.

Method Data of 5,011 athletes from 99 nationalities were obtained from the official websites of International Association of Athletics Federations, and World Masters Rankings in the years of 2006–2016. The Human Development Index (HDI) for each nationality was used as a marker of socioeconomic status.

Results An HDI × age group association was observed ($\chi^2 = 0.001$, $p = 0.001$, $\varphi C = 0.322$), where the analysis of frequency rate demonstrated a high prevalence of very elevated and elevated HDI in the AWR for the 100 m. For the endurance 10 k race analysis, the HDI × age group association was also observed, with a high prevalence of moderate and low HDI in Junior and Professionals. Regarding the Masters, the prevalence of moderate and low HDI is almost zero. In addition, multiple linear regressions indicate that the HDI, gross domestic product per capita (GDP/capita) and population can predict the frequency of a country in athletics ranking.

Conclusions There is a high prevalence of elevated and very elevated HDI nationalities in the AWR in sprint races in all age groups. For endurance races, Junior and Professionals had a great prevalence of low/moderate HDI, and Masters are dominated by very elevated HDI. A nation's frequency in the World Masters Ranking could be indicative of HDI, since an association was found among them.

Keywords Sociology · Aging · Performance · Policy

Introduction

The Human Development Index (HDI) is a marker of socioeconomic status and quality of life, determined by life expectancy, years of schooling and money income "per capita" [1]. Developed by the United Nations Development Programme, this HDI might be the strongest variable to influence, together with cultural features, a favorable environment for sportive development [2]. However, the financial support to provide minimal conditions for any kind of sports practice are far from a priority in most nations, especially in middle- and low-income countries [3].

To become a professional athlete, high standards of tactical, technical, physical, cognitive and morphological aspects should be fulfilled [2, 4, 5]. Furthermore, social-environment

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influences in childhood may lead to different processes and outcomes in athletic formation and sports professionalization [3, 6, 7].

For instance, an elegant systematic review reported an association between performance index and income inequality in children [8], being that physical activity and income inequality are the strongest structural determinants of health in children and youth. From another perspective, Côté et al. [7] demonstrated that children have a higher chance of sportive success when they are born in smaller cities. On one hand, big cities may provide more possibilities for sports practice in a structured and sophisticated environment, as well as being provided with apparatus and qualified coaches [7]. On the other hand, smaller cities provide more security and space for unsupervised physical activity, which might be a fundamental aspect for child development and sport formation [2, 9].

However, the impacts of socioeconomic factors to achieve sport success at any age are still scarce in literature. In that regard, due to the popularity and low-cost practice, athletics might be a good sport modality to evaluate the possible influence of socioeconomic parameters over the final goal of any aspirant and professional athlete, a successful position at the World Ranking. Furthermore, a prevalence analysis and view of different socioeconomic status over the Athletics World Ranking (AWR) could clarify and raise questions about sports formation, professionalization and late competition (Master age groups) that go beyond morphological and physiological aspects. For example, some socio-cultural and environmental factors that influence Africans to perform better in middle and long-distance races have been pointed out. Some tribes live in high altitudes, that is, with some level of hypoxia, which in turn stimulates erythropoiesis, leading to an increase in hemoglobin, favoring a greater transportation and consumption of oxygen and, therefore, a better aerobic performance. In addition, the habits of some African people, such as walking or even running long distances to school, or some cultural practices, such as cattle expeditions, which often involve distances of up to 160 kilometers, can contribute to the adaptation to aerobic exercises [10]. These socio-cultural aspects may also have an interaction with biological ones, as demonstrated previously in studies conducted in an animal model [11, 12], possibly due to epigenetics leading to favorable transgenerational adaptations.

Thus, it is important to study the factors that influence the achievement of good positions in the AWR, because high levels of performance in the world ranking can reciprocally influence the nation's motivation on sport. From a practical perspective, such knowledge would be of great importance for track-and-field athletes and professionals working with them considering the optimization of athlete's training. Therefore, we aimed to investigate and analyze the frequency rate of nationalities from different socioeconomic status in the AWR from two distinct race categories: sprint (100 meters' dash) and endurance (10000 meters); in three age groups: Junior, Elite Professionals and Master.

Methods

The procedures used in this study were approved by the Institutional Board of the local university, with the waiver of the requirement for informed consent of the participants given the fact that the study involved the analysis of publicly available data. The study used a cross-sectional design in which all data were derived from the International Association of Athletics Federations (IAAF), World Masters Athletics and World Masters Rankings of official competitions in the years 2006 to 2016. All data are available in the websites: http://www.iaaf.org/results, http://www.mastersrankings.com/rankings/ and http://www.world-masters-athletics.org/.

Nationality and age were extracted from the 20 best male athletes of each race (100 m and 10000 m), from each age group (Junior, Elite professionals and Masters) in the years of analysis (2006–2016). Further, we added population, number of Olympic medals, gross domestic product per capita GDP/capita and HDI values for each individual corresponding to their nationality from the last report of the United Nations Development Programme [13] and Olympics Official Website (https://www.olympic.org/olympic-results). Individuals for whom there was no information about their country of birth in the official reports were excluded. A total of 5,011 athletes were included for the final analyses.

A multiple linear regression analysis was performed to verify if GDP/capita, population and HDI are able to predict the frequency of countries in the rankings. Furthermore, all samples were stratified according to the HDI classification suggested by UNDP [13]: very elevated, elevated, moderate and low. Due to the elevated and possibly heterogeneous number of Master athletes, we divided this category into three age groups: 30–49 years old (Master 50); 50–69 years old (Master 70) or higher than 70 years old (Master 110). Junior age group encompasses athletes of 18 and 19 years old; Elite Professionals do not have age limits.

Normality and homogeneity of data were assessed by Shapiro–Wilk and Levene's test, respectively. Relative frequency rate (%) of different HDI were analyzed in all three age groups: Junior ($n=380$), Elite Professionals ($n=400$) and Master ($n=4.231$). Master athletes have a disproportional number of athletes due to age groups from 30 to 100 years old. Due to the small amount of countries of low and moderate HDI classification, these two stratums were pooled in a single category. We examined the association of HDI and age group using Chi square (χ^2) and Cramer's phi (φ_C) to evaluate the magnitude of association. Further, Spearman's correlation coefficient (r) was used to test for association between all variables of interest. Alpha level was set at 0.05. All statistical analyses were performed by the statistical package IBM SPSS v.20.0 (SPSS, Chicago, USA).

Results

Data from 5.011 athletes from 99 different countries between the years of 2006 and 2016 were analyzed. Tables 1 and 2 show the top three best medalist countries in 100 m (Table 1) and 10000 meters (Table 2), their respective HDI and number of medals.

Multiple linear regression resulted in a statistically significant model [$F(3.2734)=801.858$; $p<0.001$; $R^2=0.468$]. It was verified that GDP/capita ($\beta=0.314$; $p<0.001$), population ($\beta=-0.160$; $p<0.001$) and HDI ($\beta=-0.893$; $p<0.001$) are predictors of frequency of countries. A HDI × race distance association was observed, where frequency rate analysis demonstrated a high prevalence of very elevated and elevated HDI in the World Ranking in the 100 m, with a relative rate of more than 50% in all race categories. We further identified a small prevalence (< 30%) of moderate and low HDI in Master age groups for this same race (Fig. 1a).

For the endurance race analysis, the same HDI × age group association was observed, with a high prevalence of moderate and low HDI in groups of Junior and Elite Professionals for the 10 k (80% and more than 85%, respectively in the world rankings). Regarding Masters age groups, the prevalence of moderate and low HDI is almost zero (Fig. 1b).

The Spearman's correlation coefficient analysis in 100 meters dash revealed positive and significant association between the frequency rate in Master Athletics Ranking and HDI ($r = 0.44$; $p < 0.01$). However, significant associations were not observed in Elite Professionals and Junior

Table 1 Top 3 countries, number of medalists in the world rankings from 2006 to 2016 and their respective HDI, and HDI stratum in the race of 100 meters

Countries	Medals	HDI	HDI stratum
Masters			
United States of America	202	0.915	Very elevated
Japan	26	0.891	Very elevated
Great Britain	24	0.907	Very elevated
Overall			
Jamaica	17	0.719	Elevated
United States of America	10	0.915	Very elevated
Bahamas	1	0.79	Very elevated
Junior			
United States of America	14	0.915	Very elevated
France	4	0.888	Very elevated
Jamaica	3	0.719	Elevated

Table 2 Top 3 countries, number of medalists in the world rankings from 2006 to 2016 and their respective HDI, and HDI stratum in the race of 10000 meters

Countries	Medals	HDI	HDI stratum
Masters			
Great Britain	33	0.907	Very elevated
Spain	31	0.876	Very elevated
Australia	29	0.935	Very elevated
Overall			
Kenya	13	0.548	Moderate/low
Ethiopia	10	0.442	Moderate/low
Eritreia	2	0.391	Moderate/low
Junior			
Kenya	16	0.548	Moderate/low
Ethiopia	11	0.442	Moderate/low
Uganda	2	0.483	Moderate/low

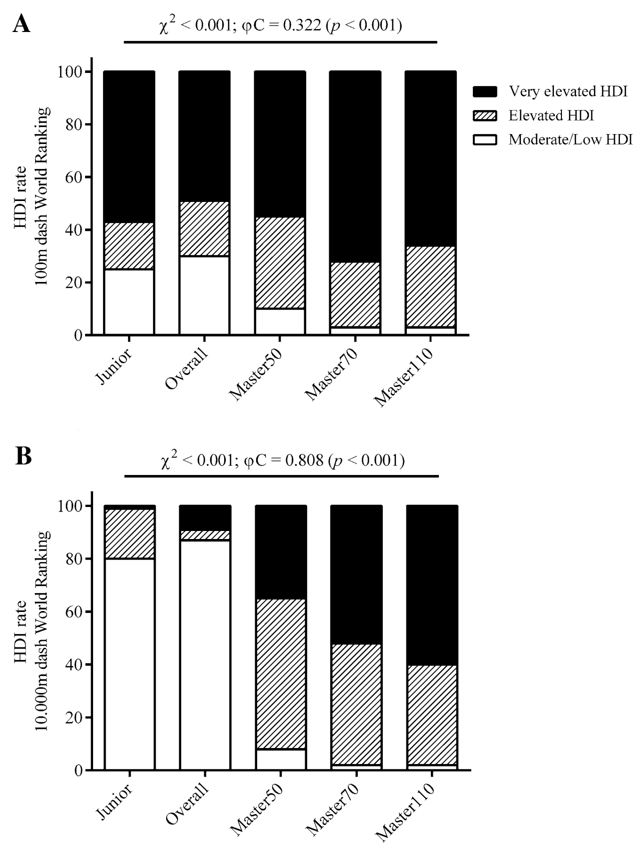

Fig. 1 Relative frequency rate analyses of countries from different Human Development Index stratums (very elevated; elevated; and moderate/low) of World Athletics Ranking from: Junior, Overall and Masters categories. **A** 100 m dash; **B** 10000 meters

(Table 3). Regarding 10.000 meters race analysis, Spearman's correlation coefficient revealed a positive and significant association between the frequency rate in Masters Athletics Ranking and HDI ($r = 0.62$; $p < 0.01$). These same associations were not observed in Elite Professionals. Junior AWR presented a negative association with HDI ($r = -0.36$; $p < 0.01$) (Table 3).

Discussion

The main findings of the present investigation were that sprint AWR is dominated by countries of very elevated socioeconomic status in all three age groups: Junior, Elite Professionals and Masters. On the other hand, endurance AWR has great prevalence of moderate/low HDI countries in Junior and Elite Professionals, but is overruled by elevated and very elevated HDI in Master age groups. Thus, at least for the Masters' category, the nation's frequency in the World Masters Ranking could be a strong indicator of HDI, since an association was found among them.

It has already been demonstrated that recreational physical activity and sport performance are positively associated with the socioeconomic status both in children [3, 14], and adults [15, 16]. Similarly to the present study, Jayantha, Ubayachandra [16] demonstrated that variables such as size of population, GDP per capita, HDI, political system (whether communist or not) and host country advantages greatly influence the Olympic success (gold medals). However, sports practice is also determined by the culture surrounding the society [17]. For example, most North American universities still maintain cultural values and practices from their foundations, including short races in athletics [17, 18]. The prevalence of countries of very elevated HDI in the 100 m dash rankings may be because sprint athletes, differently from middle- and long-distance runners, need structured athletic teams to remain at the top level. Sprinters depend on the support of coaches and specialized physical trainers, specific implements (hurdles, starting blocks, spike shoes, sleds, and elastic bands) besides synthetic track. In addition, access to gyms is an important key for muscular strength and power development, which is fundamental for sprinters [19]. Moreover, these athletes need to accelerate muscle recovery, and, as a strategy, they require a higher protein intake [19, 20]. All of these resources, as well as public policies for athletic training and continuity of practice, depend on financial investments. Thus, countries with higher HDI tend to have better socioeconomic resources for such support and, thus, the higher frequency of athletes in world rankings. On the other hand, less developed countries, like many of the African continent, have mastery in events of middle- and long-distance running, which can be the result of a culture fed by decades [21]. Some sociocultural aspects, such as using walking or running as the sole means of transport, the interbreeding of cattle between tribes, besides food privation are arduous conditions faced by the African people. This life of deprivation and the ability to endure (mentally and physically) suffering lead the African child in a good position to accept, resist and complete high training volumes that is a prerequisite for medium- and long-distance running. We also need to point out their motivation for endurance training due to the possibility of social ascension through sport [22, 23].

Table 3 Spearman's correlation coefficient analysis between Human Development Index and absolute rate in World Athletics Ranking of Junior, Elite Professionals and Masters for the 100 m dash and 10,000 m running

World Athletics Ranking (*n*)	Human Development Index	
	Correlation (*r*)	*p* value
100 m		
Junior	0.10	0.39
Elite Professionals	0.10	0.38
Master	**0.44**	**< 0.01**
10000 m		
Junior	**− 0.36**	**< 0.01**
Elite Professionals	− 0.03	0.79
Master	**0.62**	**< 0.01**

Bold values indicate $p < 0.05$

However, even in difficult living conditions, children living in Africa (mainly in rural areas) live a life that focuses predominantly on outdoor activities, such as typical games, jumps, races and games associated with livestock. Lack of financial resources, coupled with the coverage of long distances on foot and (still) minimal Western influence, provides for African children an environment favorable to physical activity compared to children in developed countries. In addition, the accumulated years of running to school were proposed as a factor that contributes significantly to the development of Kenya and other East African runners [24, 25]. Furthermore, to achieve sport success which includes frequent participation in World Championships and Olympics in their respective modalities, both scientific and sporting communities recognize that genetic factors contribute to athletic performance [26]. Every sport has unique physical requirements, for instance, aerobic endurance (the ability to sustain aerobic effort over time) has a great demand from central factors, such as cardiovascular and respiratory systems. On the other hand, sprint races (100 m dash, for example) depend on neural and musculoskeletal strength to generate maximal power [20].

Further, another noticeable characteristic between athletes of different specialties is body morphology, in which specific body types may be naturally suited to specific modalities. In that regard, many important aspects of sports performance can come from heritability [27], for instance, about 80% of the variation to determine the height is due to genetic factors [28], body type (mesomorphic, ectomorphic) is also highly heritable [29], and both are classically associated with power or endurance success [30]. Therefore, good gene combinations to better achieve endurance or strength performance can be inherited from different parts of the globe regardless of socioeconomic factors. Thus, a solid and good socioeconomic basis is fundamental to stimulate sports practice through adequate physical structure, identifying young talents and leading them to their full potential.

Similarly, to continue sports practice in the second half of life also depends on adequate structure. Master athletes usually continue their training across decades, adhering to training regimens of three to six sessions per week [31]. Nevertheless, a critical difference between Junior or Elite Professionals and Master athletes is the financial support, whereas professionals (or aspirants) have minimal financial support to dedicate more time to training or travel to important competitions, Master athletes usually have other professions and use master sports practice as a hobby to grow old in a healthy manner [32]. Thus, the low prevalence of low/moderate HDI in Master age groups may be a reflection of poor sports practice during aging in these countries. Nonetheless, it has already been demonstrated that the greater the socioeconomic status, the lower the chances of having sedentary-related diseases, such as obesity, type 2 diabetes and hypertension [33, 34].

A limitation of the present study was that it analyzed only male athletes. Considering the sex differences in participation and performance trends in running events [35, 36], caution would be needed to draw inferences for female athletes based on our findings. However, to the best of our knowledge, this is the first investigation to assess and analyze socioeconomic status in the AWR of different age groups and, therefore, the present analysis may be robust enough to provide a general idea of this unexplored context. Public policies should be directed towards mass participation in sports, in all categories, including those old enough to participate in Masters. This would be an important vehicle for the promotion of health and quality of life during aging, and therefore, disease prevention and mitigation of financial expenses with medical treatment. Moreover, nationalities' frequency in Masters' AWR would be a possible indicator of a country's Human Development Index.

Conclusions

In conclusion, there was a high prevalence of elevated and very elevated HDI countries in the AWR for sprint races in all age groups. In endurance races, Junior and Elite Professionals had a great prevalence of low/moderate HDI nationalities, while Masters' categories were dominated by elevated and very elevated HDI nationalities. Once a socioeconomic status was associated with an elevated frequency rate in the Masters' rankings in both sprint and endurance, the frequency in the World Masters Ranking could be indicative of a nation's Human Development Index.

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Compliance with ethical standards

Conflict of interest No potential conflict of interest relevant to this article was reported.

Human and animal rights All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional research committee and with the 2012 Helsinki declaration.

Informed consent Informed consent was obtained from all individual participants included in the study.

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