Performance progression in Brazilian middle-distance runners from early training to peak performance: a pilot study

Evolução da performance de meio-fundistas Brasileiros da formação ao pico de rendimento: um estudo piloto

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Abstract – The aim of this study was to evaluate performance progression in Brazilian middle-distance runners based on the progression of their sports results from early training to peak performance. The sample consisted of the 10 best performance times (800 m and 1500 m) achieved by male runners aged 15 to 19 years in national rankings between 2001 and 2010. The 800-m performance times estimated with the models were 119.14±1.79 s at 15 years of age; 114.36±1.07 s at 16 years; 113.25±1.81 s at 17 years; 110.71±1.60 s at 18 years, and 109.73±1.17 s at 19 years. The prediction of 1500-m performance was 253.89±4.84 s at 15 years of age; 243.40±1.67 s at 16 years; 238.53±1.55 s at 17 years; 232.49±1.59 s at 18 years, and 230.48±2.28 s at 19 years. It is concluded that Brazilian male middle-distance runners achieve their best performance at 22.69±0.42 years of age in the 800-m event and at 22.29±0.34 years in the 1500-m event. These values are within the lower limit described in the literature as optimal age.

Key words: Athletics; Sports performance; Training.

Resumo – *O objetivo deste estudo foi analisar a evolução da performance dos corredores de Meio-Fundo Brasileiros com base na progressão dos resultados desportivos obtidos no processo de formação e no pico de rendimento. A amostra constituiu-se dos dez melhores tempos dos rankings nacionais de 2001 a 2010, alcançados pelos corredores nas provas de MF, na faixa etária de 15 a 19 anos, do sexo masculino. Os resultados expressos pelo modelo matemático encontrado apresentam para os 800m aos 15 anos: 119,14±1,79s; 16 anos: 114,36±1,07s; 17 anos: 113,25±1,81s; 18 anos: 110,71±1,60s; 19 anos: 109,73±1,17s. Para os 1.500m constatou-se uma predição da performance aos 15 anos em: 253,89±4,84s; 16 anos: 243,40±1,67s; 17 anos: 238,53±1,55s; 18 anos: 232,49±1,59s; 19 anos: 230,48±2,28s. Conclui-se que a idade ótima de obtenção dos melhores resultados desportivos para os corredores de MF do sexo masculino, no Brasil, em provas de 800m, apresenta-se aos 22.69±0.42 anos e nas provas de 1.500m aos 22.29±0.34 anos. Estes valores situam-se no limite inferior do referido na literatura.*

Palavras-chave: *Atletismo; Performance esportiva; Treinamento.*

INTRODUCTION

Since 1979, when Agberto Guimarães obtained his first victories, until 1991 with medals won in the Athletics World Championship in Tokyo, Brazilian middle-distance runners have not been successful internationally. Thus, investigations are needed to provide possible answers and explanations for this phenomenon. Research on the performance in athletics has focused mainly on competitive and/or elite middle-distance running in an attempt to obtain more factual support. These studies include the investigation of training methods[1,2], bioenergetics of running[3], physiological, anthropometric and motor characterization[4,5], and control of training[6,7]. Performance has been analyzed using mathematical models in different sports such as cycling[8,9], swimming[10,11] and javelin throw[12], for the comparison of different sports modalities[13], and for the prediction of results in athletics events[14,15].

The increasing importance of sporting success and the prestige rapidly achieved in sports have resulted in the fact that a large number of children and adolescence participate in sports activities. However, these youngsters are often submitted to training programs of high intensity and duration which are not always compatible or adjusted to their needs[1]. Despite the consolidation of sports training methods, youth sport continues to be ruled by the sports guidelines of adults. As a consequence, adult training tends to be adapted by introducing slight alterations and doubtful pedagogical adaptations. In general, athletic training of children and adolescents seems to follow the training trends observed for adults.

In view of the above considerations and the many questions that remain unanswered, the aim of the present study was to characterize the typical performance progression in Brazilian middle-distance running over the years of training from early training to peak performance.

METHODOLOGICAL PROCEDURES

A prospective descriptive study using existing quantitative data was conducted. The sample consisted of the 10 best performance times achieved by male runners in 800-m and 1500-m events over the last 10 years (2001 to 2010) according to age (15 to 19 years). The data were obtained from the Brazilian Athletics Confederation[16]. After data collection, the mean and respective standard deviation of the ten best 800-m and 1500-m times between 2001 and 2010 were calculated.

Mathematical model
The following mathematical model was used to calculate the optimal age to achieve best performances according to distance[17].

- Step 1: the performance times analyzed were converted into a score system. This system was based on a function in which a score of 1,000 points was attributed to the absolute national record (ANR) of each

race. Next, a specific constant (C_{race}) was calculated for the 800-m and 1500-m events:

$$C_{race} = ANR^3 * 1000$$

On the basis of the numerical value of each constant, a corresponding individual score (CIS) was attributed to each individual time (IT) according to the following function:

$$CIS = C_{race} * IT^{-3}$$

- Step 2: In order to express the test score in relation to age, we used the mean time of the 10 best runners for all ages obtained from the updated ranking table of the Brazilian Athletics Confederation. This procedure intended to enable that the score corresponding to a given time would be coherent with the constraint provided by the ANR for the test in question and the athlete's age when this time was obtained.

Statistical analysis

A linear regression model was used to predict the optimal age to achieve best performances using the five pairs of known data (age and mean score at 15 to 19 years of age), thus obtaining the age at which the score of 1,000 points (corresponding to the ANR) would be achieved.

RESULTS

The performance times used for construction of the regression model at each of the two distances studied are shown in Table 1. Table 2 shows the results of regression analysis of the rankings of Brazilian middle-distance runners for calculation of the age at which the best performance times were achieved in each event. The athletes tend to achieve their best times between 22-23 years of age in the two events.

Table 1. Results of the 10 best rankings in each event according to age.

| Event	Age (years)	Mean time (s)	Mean speed (km/h)	Standard deviation (km/h)
800 m	15	119.14	24.17	1.79
	16	114.36	25.19	1.07
	17	113.25	25.43	1.81
	18	110.71	26.01	1.60
	19	109.73	26.24	1.17
1500 m	15	253.89	21.26	4.84
	16	243.40	22.18	1.67
	17	238.53	22.63	1.55
	18	232.49	23.22	1.59
	19	230.48	23.42	2.28

Table 2. Linear regression equations to estimate the age at which the best performance time is achieved.

| Event	Linear equation	Predicted age	R	R²	Standard error of the estimate
800 m	Age = 0.022*score + 0.694	22.69	0.973	0.946	0.423
1500 m	Age = 0.019*score + 3.29	22.29	0.982	0.964	0.347

Analysis of the progression of sports results over time (Figure 1) shows a similar trend at 800 m and 1500 m. Figures 2 and 3 compare the true values obtained in each event with the values predicted using the mathematical models according to age.
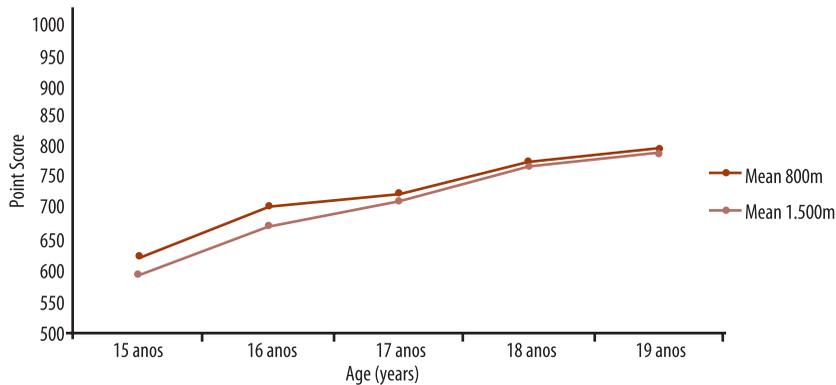
Figure 1. Performance progression (point score) with age at the two distances.
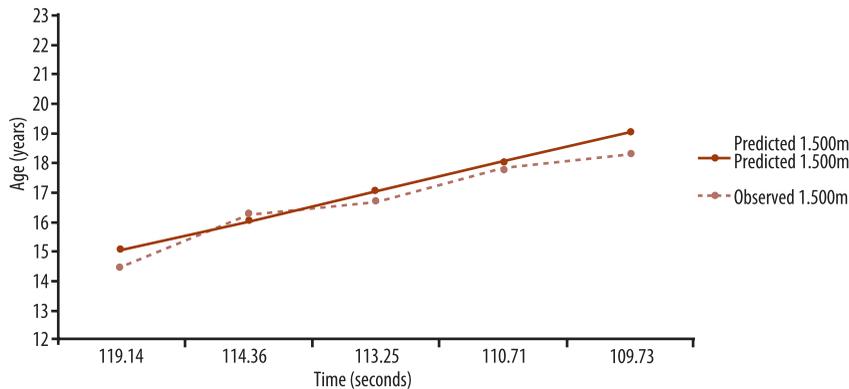
Figure 2. Graphic representation of the 800-m performance times predicted with the mathematical model proposed.
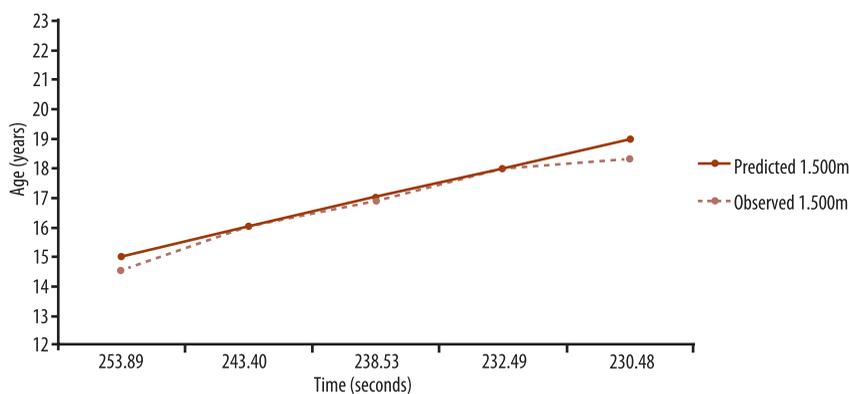
Figure 3. Graphic representation of the 1500-m performance times predicted with the mathematical model proposed.

DISCUSSION

The objective of the present study was to evaluate performance progression in Brazilian middle-distance runners based on the progression of the results from early training to peak performance. This study sought to answer the following question: Why does the high level of sports results in Brazilian middle-distance running obtained during the last two decades of the 20th century seems to be difficult to achieve at present?

The present results indicate that male middle-distance runners in Brazil tend to achieve their best performance times at about 22-23 years of age. This finding agrees with the age reported in the international literature for middle-distance runners, who achieved the best results between 23 and 27 years[18]. Nevertheless, the values found are within the lower limit of the range reported, a fact suggesting the need for careful analysis of the growth curve of performance times as a function of age. Assuming that the rational preparation of a career in sports designed to achieve the best sports results should comprise 8-12 years of special-ized training, the present results identify an age at onset of specialized training of about 12 years for male middle-distance runners in Brazil, a value that is below that proposed in the literature[18]. As a consequence, either Brazilian athletes tend to start their specialization too early, or they start at the recommended age (14-15 years), but the training design subsequently prevents progression from continuing for 10 or more years which is necessary to achieve peak performance. The need to start specific training early usually results in an inadequate understanding of the basic principles that guide long-term sports preparation[2]. Studies involving pre-juniors and juniors who represented the different associations of Portugal in the 1987 national final competitions of the Portuguese Track and Cross Country Championship are an example of this by identifying children who start to be specialists in middle- and long-distance races at 6 years[7]. In contrast, another trend was observed in France. A study retrospectively investigating the 20 best French athletes of all athletics disciplines in 1994 found that the mean age at the beginning of athletics was 13.9 ±1.4 years for all disciplines[1].

On the basis of the analysis of the growth curves of the sports results and of the optimal age to achieve the best times in middle-distance events, it is possible to establish an operational method to define long- and medium-term (career plan and steps of sports training) and short-term objectives (training season). Designing a career plan based on the establishment of performance objectives is what is done universally in all sports. However, the definition of these objectives is not always adequate and the consequence is the failure in sports. The management of sports results through success or failure in the performance of a competitive task has been advocated in swimming[19,20]. This approach seems to be equally necessary in athletics, at least in the case of running modalities. The approach used in this study permitted to identify possible sources of temporal misalignment in the

design of the sports career of Brazilian middle-distance runners. It should be noted that this phenomenon (possible misalignment in career design) is somehow common among the best young athletes from America and the world in youth categories, with the lack of confirmation of good results when these athletes become adults. This fact may be avoided if the planning of the training method is divided into steps, ruling out the hypothesis of early specialization and contributing to achieve maximum performance in the future[1,21].

The progression of performance over the age range studied here was clearly not only due to the process of training, but was also the result of physical maturation and growth. The effectiveness of aerobic training in boys is greater once the peak growth velocity is reached (until 14 years). Biologically, this seems to make sense considering the changes that occur in endocrine function during this stage of development. This is one of the reasons why aerobic activity has priority over anaerobic activity in runners. Although maximum VO_2 levels expressed relative to body weight are relatively stable or decline with age, aerobic capacity improves in a constant manner during growth[19]. However, since in most cases growth velocity reaches its peak by age 15, the maturation processes lose their influence on physical fitness from that age on. As a consequence, height and body weight growth reach their maximum at around 14 years of age in boys and have a marked influence on the development of motor skills[19], with substantial improvement in resistance, strength, speed, and power[18] and a consequent impact on competitive performance[21].

The existence of a second pubertal spurt[19] may equally contribute to the understanding of the results (Figure 1). Analysis of the results and literature data shows that we are witnessing a second evolutionary spurt in sports results, which may have occurred simultaneously with this biological phenomenon. This phenomenon is seen particularly in boys who present major increases in force production capacity that influence speed and performance[19].

CONCLUSIONS

The optimal age of Brazilian male athletes to achieve the best results in 800-m and 1500-m middle-distance running is 22.69 ± 0.42 and 22.29 ± 0.34 years, respectively.

These values are within the lower limit reported in the literature and further studies are needed to confirm this trend. If confirmed, these results indicate a temporal misalignment between the optimal period of physical and technical maturation of Brazilian middle-distance runners and the requirements encountered during training and competition.

In addition, the sports results indicate two points of performance declines at 15 and 19 years, a finding that also requires further confirmation and discussion. Future studies investigating the influence of training and

physical maturation on performance progression with age should include other variables, such as training time and age at the onset of training.

REFERENCES

1. Borin JP, Gonçalves A. Alto nível de rendimento: a problemática do desempenho desportivo. Rev Bras Ciênc Esporte 2004;26(1):9-17.

2. Cafruni C, Marques A, Gaya A. Análise da carreira desportiva de atletas das regiões sul e sudeste do Brasil. Estudo dos resultados desportivos nas etapas de formação. Rev Port Cien Desp 2006;(6):55-64.

3. Caputo F, Oliveira MFM, Greco CC, Denadai BS. Exercício aeróbio: aspectos bioenergéticos, ajustes fisiológicos, fadiga e índices de desempenho. Rev Bras Cineantropom Desempenho Hum 2009;11(1):94-102.

4. Hegg RV. Estudo antropométrico - campeonato juvenil de atletismo - São Paulo. Rev Bras Ciênc Esporte 1982;(3):63-79.

5. Kruel LFM, Tartaruga LAP, Coertjens M, Oliveira AS, Ribas LR, Tartaruga MP. Influência das variáveis antropométricas na economia de corrida e no comprimento de passada em corredoras de rendimento. Motriz 2001;13(1):01-06.

6. Gomes AC, Suslov FP, Nikitunskin, V.G. Atletismo: Preparação de corredores juvenis nas provas de meio-fundo. Londrina: CID, 1995.

7. Colaço P. Métodos de avaliação da prestação anaeróbia. Treino Total. 2000;1:22-6.

8. Underwood L, Jermy M. Mathematical model of track cycling: the individual pursuit. Procedia Engineering 2010;2(32):17-22.

9. Martin JC, Gardner AS, Barras M, Martin DT. Modeling sprint cycling using field-derived parameters and forward integration. Med Sci Sports Exerc 2006;592-97.

10. Avalos M, Hellard P, Chatard JC. Modeling the training-performance relationship using a mixed model in elite swimmers. Med Sci Sports Exerc. 2003;(35):838-46.

11. Okičić T, Madić D, Dopsaj M, Đorđević M. The math modeling of the stages of result development in high profile elite swimmers for the 50m, 100m, 200m, 400m and 1500m freestyle. Phys Educ Sport 2007;5(2):121-37.

12. Maryniak J, Kozdraś EL, Golińska E. Mathematical modeling and numerical simulations of javelin throw. Hum Mov 2009;10(1):16-20.

13. Baker AB, Tang YQ. Aging performance for masters records in athletics, swimming, rowing, cycling, triathlon, and weightlifting. Exp Aging Res. 2010;36(4):453-77.

14. Alvarez-Ramirez J. An improved Peronnet-Thibault mathematical model of human running performance. Eur J Appl Physiol 2002;86(6):517-25.

15. García-Manso JM, Martín-González JM, Vaamonde D, Da Silva-Grigoletto ME. The limitations of scaling laws in the prediction of performance in endurance events. J Theor Biol 2012;26(300):324-29.

16. Confederação Brasileira de Atletismo. Ranking anos anteriores. Available from: <http://www.cbat.org.br/estatisticas/ranking_outros_anos.asp.> [2011 mar 07].

17. Van Tilborgh L, Willems EJW, Persyn U. Estimation of breaststroke propulsion and resistance resultant impulses from film analysis. In: Ungerechts B, Wilke K, Reischle K, editors. Swimming science V (International series on sport sciences 18), Champaign (Illinois): Human Kinetics; 1988. p. 67-72.

18. Linets M, Orenchak I. Age differences in establishing and maintaining skill in middle- and long-distance running. Fitness Sports 1992;27(4):138-43.

19. Silva AJ, Reis V, Gudetti L, Simões P, Carneiro, A, Raposo JV, et al. Análise da evolução da carreira desportiva de nadadores do sexo masculino utilizando a modelação matemática. Rev Treino Desportivo 2006;7(1):50-7.

20. Silva AJ, Marinho D, Carvalhal IM, Durão M, Reis V. Carneiro A, et al. Análise da evolução da carreira desportiva de nadadores do gênero feminino utilizando a modelação matemática. Rev Bras Med Esporte 2007;13(3):175-180.

21. Coquart JB, Bosquet L. Precision in the prediction of middle distance-running performances using either a nomogram or the modeling of the distance-time relationship. J Strength Cond Res 2010;24(11):2920-6.

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