Original Paper DOI: 10.5604/20831862.1120933 Biol Sport 2014;31:267-270

HERITABILITY OF AEROBIC POWER OF INDIVIDUALS IN NORTHEAST BRAZIL

Accepted for publication 15.03.2014

AUTHORS: Alonso L, Souza EC, Oliveira MV, do Nascimento LFE, Dantas PMS

Department of Physical Education, Federal University of Rio Grande do Norte (UFRN) Center for Health Sciences (UFRN), Natal, RN - Brazil

Reprint request to:
Luciano Alonso
Federal University of Rio Grande do Norte (UFRN) Center for Health Sciences (UFRN) Professor, Department of Physical Education (UFRN) Campus Universitário, s/n - Departamento de Educação Física Lagoa Nova – Zip Code: 59072-970 - Natal, RN - Brazil Fone: 55 84 32155506
E-mail: alonso.lvs@gmail.com

ABSTRACT: The objective of this study was to evaluate the genetic and environmental contribution to variation in aerobic power in monozygotic (MZ) and dizygotic (DZ) twins. The sample consisted of 20 MZ individuals (12 females and 8 males) and 16 DZ individuals (12 females and 4 males), aged from 8 to 26 years, residents in Natal, Rio Grande do Norte. The twins were assessed by a multistage fitness test. The rate of heritability found for aerobic power was 77%. Based on the results, the estimated heritability was largely responsible for the differences in aerobic power. This implies that such measures are under strong genetic influence.

KEY WORDS: heritability, twins, aerobic power

INTRODUCTION

The growth of the sedentary lifestyle in modern industrialized society has led to a substantial increase of several morbidities and increased mortality associated with cardiovascular disease. The description and the consequences of physical inactivity have been the subject of several studies in the area of epidemiology of physical activity [1,2,3].

The analysis of satisfactory levels of physical activity involves variables intrinsic to the development of motor skills (cardiopulmonary, speed, strength and flexibility), where the assessment is an estimation method of the level of physical activity [4,5]. Each valence is exploited differently according to the type of sport practised. However, the level of physical activity depends on several factors, including the influences of genetic and environmental information [2]. These issues are highly relevant when relating the potential of an individual to perform activities and when planning training for the sport. Therefore, twin studies are viable to verify the possible genetic and environmental influences.

The focus on heritability (h^2) of motor skills through studies with pairs of twins has been a subject of discussion due to the proposition that twins are a sample of the general population and the components of each pair of twins are exposed to the same environmental influences. These possible influences, genetic and environmental, should be considered for human performance [6,7].

The choice of twins occurring in the face of genetic and environmental factors of family involvement reveal a close association between the lifestyle of the parents and their offspring [8,9]. Since the analysis of the variation in aerobic power was defined by its evaluation is the direct way to estimate high and satisfactory levels of physical activity [5,10]. The aim of this study was to evaluate the relative importance of the contribution of genetic and environmental variation to aerobic power in monozygotic and dizygotic twins.

MATERIALS AND METHODS

The participants of the study were voluntary monozygotic and dizygotic twins, residents in Natal and São Gonçalo do Amarante, Rio Grande do Norte, Brazil. At the beginning, the sample of individuals twins included 28 monozygotic (MZ) and 24 dizygotic (DZ) twins; however, 16 patients (8 MZ and DZ 8) were excluded due to the inclusion and exclusion criteria. Thus, the sample used comprised 20 MZ individuals (12 females and 9 males) and 16 DZ individuals (12 females and 4 males), aged 8 to 26 years.

Moreover, there was exclusion of study patients with physical disabilities that hindered anthropometric assessment, pregnant women, individuals in drug treatment related to obesity, patients with Down syndrome, Prader-Willi syndrome, hypothyroidism, etc. We also excluded from the study pairs of twins of different gender, pairs who did not share the same habit of physical activity, and same-gender twins who were at different stages of sexual maturation. Pairs of MZ twins who had weight and height with a difference of 5 kg or more and 5 cm or more were also excluded from the study [6].

This study was approved by the Ethics Committee of Onofre Lopes Hospital – CEP/HUOL, duly recognized by the National Research Ethics, protocol CEP/HUOL: 484/10 - CAAE: 0042.0.2.294.000-10 on 18/02/2011.

Procedures

The study participants were healthy individuals for whom the informed consent form (ICF) was signed by parents or guardians of minors 18 years of age (24 individuals). The other 12 individuals older than 18 years signed the ICF consenting to participation in the study. Determination of zygosity was made by a questionnaire, administered by telephone to mothers of twins [11]. On the day of data collection, interviews on medical history, a questionnaire to verify readiness for physical activity, PAR-Q [12] and self-assessment of sexual maturation [13] were carried out. In addition, we performed observation of the physical similarity of each pair of twins, checking the hair colour, eye colour, facial features, height and weight [11], methods by which they were classified as monozygotic or dizygotic pairs.

Subsequently, the pairs of twins were submitted to the assessment of body composition by anthropometric measurements, carried out by a properly trained assessor. The instruments used were 110 Filizola® electronic scales with a capacity of 150 kg, with a unit of 0.1 kg. Height was determined using a Sanny® anthropometer with units of measurement 0.1 cm. We measured body mass and stature, not being allowed a difference of 0.5 cm between them and, as a result, it was used as the mean of the measures. Assessments were performed on individuals with minimal clothing and no shoes. These measurements were performed in a silent room with temperature controlled between 22 and 24°C. Considering the high precision electronic scale, body mass was measured only once. With the measured weight and height, the body mass index was calculated based on the proposal from the World Health Organization [14]. The methodology used was standardized to anthropometric measurements according to the procedures described by Marfell-Jones et al. [15].

After these phases, the individuals were subjected to the test of aerobic power – the multistage fitness test [16]. We used a compact disc (CD) containing the music track of the test and a stereo high power. This test was performed on rubberized flooring and evaluated using light clothing and shoes with rubber soles. The temperature was between 24 and 26°C. Twins were tested at a maximum interval of 60 minutes to avoid possible effects of days on the test results. No twin participated in any vigorous activity or consumed alcohol or caffeine for 24 hours before testing. All were informed about the importance of getting adequate sleep the night before the procedure and all were familiar with the research.

The aerobic power was measured by an indirect method using the multistage fitness test, with R= 0.84 [17]. The test was performed as follows: Two points were marked on the floor of a gymnasium with 20 metres distance between them. Playing the music track of a beeper on a stereo, the twins took the test individually, which moved from one brand to another at a speed determined by the pace of the beep. Previously, there have been some general warm-up exercises, followed of an explanation to the participants in detail about the testing procedures. Mainly on the criterion of faults with respect to the arrival time markings, in this case three consecutive absences would determine the path the end of the test, in addition to resulting in withdrawal arising fatigue. At the end of the test, the subjects were instructed to make a return to normal, for a period of 5 minutes just walking.

All assessed individuals were verbally encouraged to reach the submaximal effort and specific determination of aerobic power. The $\dot{V}O_2$ in $ml{\cdot}kg^{-1}{\cdot}min^{-1}$ (Y) was predicted by the equation $Y = 31.025 + 3.238\,X - 3.248\,A + 0.1536\,AX$ (people 6-18 years) and $Y = 31.025 + 3.238\,X - 3.248\,A + 0.1536\,AX$ (persons 18 years or more) where X is the speed in $km{\cdot}h^{-1}$ and A is age in years [16].

Statistical analysis

Analyses were based on the variance of intra pair twins. Thus we controlled for possible confounding variables, such as sex, age and sexual maturation. All statistical analysis was performed according to the variance of the results of each pair of twins. Initially, we calculated the median and its confidence intervals (percentile 25-75).

After this stage, comparisons were made between the median of these MZ and DZ groups by the Mann-Whitney test. Additionally, the heritability of all the variables of the study was calculated, demonstrating how each variable has genotypic and phenotypic character [18].

For characters of quantitative variation, the differences between pairs of MZ twins and between pairs of DZ twins were taken, in addition to using the following formula: $h^2 = (S^2\,DZ - S^2\,MZ) / S^2\,DZ$ [8, 11], where S^2 represents the average variance of each series of differences. When $h^2 = 1$, the variance of the character is attributable solely to hereditary causes. When $h^2 = 0$, the variation is explained entirely by environmental effects. In both cases, it was assumed that the measurement errors are random and thus tend to cancel themselves.

TABLE 1. MEDIAN OF VARIANCES AND CONFIDENCE INTERVALS (CI) OF VARIABLES OF ANTHROPOMETRIC MEASUREMENTS AND AEROBIC POWER IN MONOZYGOTIC AND DIZYGOTIC TWINS

	Monozygotics (n=20)		Dizygotics (n=16)		P value
	Median	IC (25-75)	Median	IC (25-75)	
Age (years)	13.5	(12.75 -20.00)	14.5	(11.25 - 22.5)	1.00
Body height (cm)	0.000094	(0.000036-0.000266)	0.000204	(0.00004 - 0.00141)	0.59
Body mass (kg)	1.3625	(0.36125 -3.78500)	5.21563	(0.69875 - 6.98469)	0.29
BMI ($kg \cdot m^{-2}$)	0.14761	(0.27515 - 0.39129)	1.23031	(0.46654 - 4.19935)	0.01
Aerobic power	0.83223	(0.18375-4.82000)	1.2961	(0.00281-18.04785)	0.86

RESULTS

We found a significant difference between the medians of the variance in BMI. The BMI estimate of heritability (h^2) was 0.80 (80%). The variables height, body mass and aerobic power did not show significant differences when compared to their medians. The height h^2 presented 0.64 (64%); body mass obtained h^2 0.74 (74%), and aerobic power obtained h^2 0.77 (77%).

DISCUSSION

This study had provided new evidence on individual differences in aerobic power in individuals in north eastern Brazil, indicating that these may be largely attributed to genetic differences.

Results will be discussed in light of relevant evidence obtained from studies of twins and with respect to the accuracy and acceptability of the method applied, which was used to assess the genetic basis of phenotypic variation [9,19,20,21-23,24].

Despite the scarcity of data on the heritability of aerobic power in samples of the population, some international studies have reported significant genetic influence of great aerobic power. Estimates of heritability, although high, showed a wide range of variation in studies approximately 10% to 80%, depending on the adjustments [25,26,27,28]. These results agree with the findings of this study which found high genetic dependence for aerobic power, with an estimated heritability of 0.77 (77%), and have shown that the possible influence of ethnic individuals born in the north eastern region of Brazil did not influence our findings.

Corroborating our study, Bouchard [25] found that the training capacity for aerobic power is highly familiar and includes a significant genetic component. However, there are considerable individual differences in these phenotypes in relation to training answers.

This considerable variation in results can be attributed to different methods of assessment, and the interaction of biological and behavioural factors linked to this type of motor ability. Thus this study has sought to meet strict criteria regarding the evaluation test used to measure aerobic power and the use of the method of twins in order to minimize the involvement of factors that could decrease the robustness of the results [16].

Heritability estimates may vary for different age groups, suggesting that the maturational stage has interfered with test results. Moreover, it is known that some children, when compared to their peers of the same chronological age, may show differences in the results of physical fitness tests, due to the influence of biological maturity [29]. Thus, in this study we used a gradient of age, excluding from the study those who showed different intra pair maturational stages.

These findings have sought to elucidate the genetic effect on individual differences in aerobic power, taking the possible ethnic influences in our sample into account. Furthermore, these results may provide a better understanding of the variation of performance in physical fitness of the population and the training of sports that require high aerobic power phenotypes, such as football, basketball, handball, futsal, tennis players and runners.

Limitations of the study: The limitation of the study was the small sample size due to the difficulty of finding pairs of twins who agreed with the inclusion criteria.

Originality of the study: This study had the merit of generating evidence on the heritability of aerobic power using the method of twins. From these findings we intend to elaborate a classification of levels of heritability, in which inferential statistics will be used from quartiles. Thus, the study of heritability brings the physical education professional the ability to understand the possible environmental influence which supports the training methodologies in sports and school levels.

CONCLUSIONS

Based on these results, it is concluded that aerobic power has proved to be a highly heritable trait in individuals of both sexes, in north eastern Brazil, from 8 to 26 years of age. We recommend further studies on this topic to better comprehension of the development of aerobic power.

Conflict of interest: none declared.

REFERENCES

1. Hallal PC, Samuel SC, Bastos JP, Reichert FF, Siqueira FV, Azevedo MR. Evolution of the epidemiological research on physical activity in Brazil: a systematic review. Rev Saúde Pública. 2007;41(3):453-60.
2. Hallal PC, Wells JCK, Reichert FF, Anselmi L, Victora CG. Early determinants of physical activity in adolescence: prospective birth cohort study. BMJ. 2006;332(7548):1002.
3. WHO. The world health report 2002: reducing risks, promoting healthy life. World Health Organization; 2002.
4. Ilha PMV, da Silva RCR, Petroski EL. Validity of tritrac tri-axial accelerometer: a review of literature. Rev Bras Cine Des Hum. 2005;1415:8426.
5. Pardini R, Matsudo S, Araújo T, Matsudo V, Andrade E, Braggion G, Andrade DR, Oliveira LC, Figueira Júnior AJ, Raso V. Validation of the International Physical Activity Questionnaire (IPAQ version 6): pilot study in Brazilian young adults. Braz J Sci Movement. 2008;9(3):45-52.
6. Bouchard C, Hoffman EP. Genetic and molecular aspects of sports performance. Chennai, India: Wiley Online Library; 2011.
7. Sousa EC, Oliveira MV, Tenório F, Pinto VCM, Alonso LVS, Dantas PMS. Heritability in women and men of muscle strength of upper and lower limbs. Sport Med J. 2013;9(3): 2171-6.
8. Seabra AF, Mendonça DM, Thomis MA, Anjos LA, Maia JA. Biological and socio-cultural determinants of physical activity in adolescents. Cad Saúde Pública. 2008;24(4):721-36.
9. Segal NL, Feng R, McGuire SA, Allison DB, Miller S. Genetic and environmental contributions to body mass index: comparative analysis of monozygotic twins, dizygotic twins and same-age unrelated siblings. Int J Obes. 2009;33(1):37-41.
10. Treuth MS, Hou N, Young DR. Validity and reliability of the fels physical activity questionnaire for children. Med Sci Sports Exerc. 2005;37(3):488-95.
11. Peeters H, Van Gestel S, Vlietinck R, Derom C, Derom R. Validation of a telephone zygosity questionnaire in twins of known zygosity. Behav Genet. 1998;28(3):159-63.
12. Thomas S, Reading J, Shephard RJ. Revision of the Physical Activity Readiness Questionnaire (PAR-Q). Can J Sport Sci. 1992.
13. Tanner JM. Growth and maturation during adolescence. Nutr Rev. 1981;39(2):43-55.
14. Onis M, Onyango A, Borghi E, Siyam A, Nishida C, Siekmann J. Development of a WHO growth reference for school-aged children and adolescents. Bulletin of the World Health Organization. 2007;85:660-7.
15. Marfell-Jones M, Olds T, Stewart A, Carter L. Potchefstroom, South Africa. International standards for anthropometric assessment: ISAK. 2006.
16. Léger LA, Mercier D, Gadoury C, Lambert J. The multistage 20 metre shuttle run test for aerobic fitness. J Sport Sci 1988;6(2):93-101.
17. Duarte MFS, Duarte CR. Validity of the maximal multistage 20m shuttle run test. Rev Bras Ciên e Mov. 2001;9(3):7-14
18. Clark PJ. The heritability of certain anthropometric characters as ascertained from measurements of twins. Am J Hum Genet. 1956;8(1):49.
19. Bogl LH, Latvala A, Kaprio J, Sovijärvi O, Rissanen A, Pietiläinen KH. An investigation into the relationship between soft tissue body composition and bone mineral density in a young adult twin sample. J Bone Miner Res. 2010;26(1):79-87.
20. Bouchard C. Childhood obesity: are genetic differences involved? Am J Clin Nutr. 2009;89(5):1494S-501S.
21. Leskinen T. Differences in muscle and adipose tissue gene expression and cardio-metabolic risk factors in the members of physical activity discordant twin pairs. PLoS One. 2010;5(9):1-9.
22. Leskinen T, Sipilä S, Alen M, Cheng S, Pietiläinen KH, Usenius JP, Suominen H, Kovanen V, Kainulainen H, Kaprio J, Kujala UM. Leisure-time physical activity and high-risk fat: a longitudinal population-based twin study. Int J Obesity. 2009;33(11):1211-8.
23. Liu A, Byrne NM, Kagawa M, Ma G, Kijboonchoo K, Nasreddine L, Koon Poh B, Ismail MN, Hills AP. Ethnic differences in body fat distribution among Asian pre-pubertal children: a cross-sectional multicenter study. BMC Public Health. 2011;11(1):500.
24. Mutikainen S, Perhonen M, Alén M, Leskinen T, Karjalainen J, Rantanen T, Kaprio J, Kujala UM. Effects of long-term physical activity on cardiac structure and function: A twin study. J Sport Sci Med. 2009;8(4):533-42.
25. Bouchard C, An P, Rice T, Skinner JS, Wilmore JH, Gagnon J, Pérusse L, Leon AS, Rao DC. Familial aggregation of VO2 max response to exercise training: results from the HERITAGE Family Study. J Appl Physiol. 1999;87(3):1003-8.
26. Bouchard C, Daw EW, Rice T, Pérusse L, Gagnon J, Province MA, Leon AS, Rao DC, Skinner JS, Wilmore JH. Familial resemblance for VO2max in the sedentary state: the HERITAGE family study. Med Sci Sports Exerc. 1998;30(2):252-8.
27. Bouchard C, Lesage R, Lortie G, Simoneau JA, Hamel P, Boulay MR, Pérusse L, Thériault G, Leblanc C. Aerobic performance in brothers, dizygotic and monozygotic twins. Med Sci Sports Exerc. 1986;18(6):639-46.
28. Fagard R, Bielen E, Amery A. Heritability of aerobic power and anaerobic energy generation during exercise. J Appl Physiol. 1991;70(1):357-62.
29. Jones MA, Hitchen P, Stratton G. The importance of considering biological maturity when assessing physical fitness measures in girls and boys aged 10 to 16 years. Ann Hum Biol. 2000;27(1):57-65.