Science & Sports (2020) xxx, xxx—xxx

Disponible en ligne sur ScienceDirect www.sciencedirect.com

Elsevier Masson France EM|consulte www.em-consulte.com

LETTER TO THE EDITOR

Assessing blood pressure in basketball youth players during astrand testing using percentiles

Évaluer la pression artérielle des jeunes joueurs de basket-ball lors d'un test astringent à l'aide de percentiles

1. Case itself

Arterial hypertension (HBP) is a major cardiovascular risk factor that affects a high percentage of the adult population [1]. In the last decades, an increase in blood pressure (BP) has been observed in children and adolescents, which supports the recommendation that BP should be measured in children during clinical examinations [2]. HBP is also a cardiovascular risk factor in children and adolescents and may lead to the development of HBP in adulthood [2]. Therefore, HBP in childhood should be prevented to reduce cardiovascular risk in adulthood. Then, it is necessary to define the parameters that identify the children at high cardiovascular risk [3]. In Aragon—a northern province of Spain—sports medical exams (SME) are massively performed on schoolchildren following a protocol that includes measurement of blood pressure at rest and after submaximal exercise testing (Astrand Step Test). The aim of sports medical exams is to promote early detection through screening and determine the subject's suitability for physical activity. Although the SME report includes the measurement of exercise blood pressure (EBP), there are no reference values for BP levels in children and adolescents. The only reference values available are for healthy adults and adults with cardiovascular disease [4—6]. The aim of this study was to define normal exercise systolic blood pressure values—or values suggestive of normality- in children after Astrand Step Testing that serve as a reference when high exercise blood pressure is detected in this age population.

Of the 3008 SME performed between 2001 and 2005, we selected a homogeneous group of 579 age- and sex-matched youth basketball players (336 boys and 243 girls aged 8 to 15 years). We chose basketball because it is the most popular sport among girls and the second most popular among boys in our region and because basketball players have special anthropometric characteristics (weight and height above normal standards). Written consent was obtained from parents and legal tutors after being explained the SME procedure, which was previously approved by the Ethics Committee of the University of Zaragoza, Spain, according to the guidelines of the Declaration of Helsinki regarding human experimentation (1974) (Table 1).

The study subjects underwent a SME, which included a revision of their medical history, examination by system, kinanthropometry, electrocardiography and submaximal Astrand Step Testing. BP was measured according to standard recommendations [3]. Resting blood pressure was measured twice by the auscultatory method and using a mercury sphygmomanometer with the patient in supine position. The mean value of both measurements was used as the final measurement value. The Astrand Step Test was performed with either a 33 or a 40 cm-high bench (33 cm for children < 150 cm and 40 cm for children > 150 cm.) for five minutes at an average frequency of approximately 22.5 step-ups per minute (21 to 24 per minute). Upon completion of the five-minute exercise test, the subjects remained in standing position, their heart rate was measured for a six-second interval (to avoid errors due to the rapid heart rate decline) and BP was immediately measured.

Exercise testing was performed according to the Regional Government of Aragon guidelines for athlete schoolchildren [7]. Contraindications and risk factors for children were taken into account before exercise testing [5,6]. Resting and exercise BP were always measured by the same observer to avoid interobserver variability [8]. Measuring EBP is challenging (subject's motion, ergometer vibrations, machine sounds and variability in measuring methods). However, taking diastolic blood pressure (DBP) is even more difficult, since sounds can be heard at pressures down to 0 mmHg [8]. In this study, to determine DBP was considered the fourth Korotkoff sound. However, this sound was not used to assess EBP response because it was barely audible and showed a limited range during the study.

Descriptive analysis was performed for all variables: means with standard error, variance, standard deviation, median, interquartile range, asymmetry, kurtosis,

https://doi.org/10.1016/j.scispo.2020.04.001

Table 1 Weight, height and body mass index by Age Groups.

Age	No.		Weight		Height		BMI	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
8	24	24	32.35 (±2.85)	34.58 (±2.43)	133.53 (±1.99)	135.03 (±1.90)	18.15 (±1.07)	18.97 (±0.8)
9	30	28	34.49 (±2.78)	36.80 (±3.02)	137.76 (±2.26)	139.86 (±1.68)	18.18 (±0.87)	18.82 (±1.08)
10	48	30	41.00 (±2.35)	40.97 (±2.25)	145.55 (±2.07)	145.86 (±2.21)	19.36 (±0.55)	19.27 (±0.48)
11	53	70	45.23 (±2.56)	45.68 (±2.03)	153.17 (±2.59)	153.06 (±1.89)	19.29 (±0.44)	19.51 (±0.38)
12	48	20	50.80 (±3.02)	52.55 (±5.55)	160.55 (±2.93)	159.00 (±3.07)	19.72 (±0.54)	20.78 (±1.4)
13	50	31	63.25 (±3.42)	54.82 (±2.86)	170.73 (±3.00)	165.13 (±3.07)	21.7 (±0.55)	20.11 (±0.29)
14	45	20	62.75 (±3.37)	60.96 (±2.47)	174.82 (±2.48)	168.33 (±3.15)	20.53 (±0.51)	21.52 (±0.07)
15	38	20	72.45 (±3.89)	59.87 (±3.26)	180.62 (±3.03)	170.78 (±3.39)	22.21 (±0.42)	20.54 (±0.3)

Weight: Kg. Height: cm. Body Mass Index (BMI): kg/m^2.

prevalence and percentiles-exclusively for exercise systolic blood pressure (ESBP). Confidence intervals were calculated at the 95% level (CI 95%) Student's t test was used for comparison of means since conditions were met in all cases. A P value = 0.05 was considered statistically significant. Weighted Average means were considered for the percentiles for ESBP. Statistical analysis was performed using the SPSS, version 13 software under the license held by the Department of Biostatistics, School of Medicine, University of Zaragoza, Spain.

Table 2 show resting and exercise systolic blood pressure and dyastolic blood pressure and heart rate during exercise. Resting BP is generally measured in children within this age range by height, age, and gender. Table 2 show that Systolic blood pressure (SBP) and DBP increase with age.

In this study, the threshold established to determine high ESBP was the same as that used for resting BP [3,9]. ESBP values ranging between the 90th and 95th percentile were considered high, whereas values exceeding the 95th percentile were considered very high (Table 3).

Since BP in children increases with age, the same phenomenon could occur to EBP; in fact, the significant differences obtained in EBP between age groups support this hypothesis (Table 2). Consequently, ESBP percentiles were calculated for two clearly distinguishable age groups (8-11 years and 12-15 years) and, as expected, remarkable differences were obtained (Table 3). In general terms, ESBP values were higher for boys than for girls: 175 mmHg (90th percentile) and 190 mmHg (95th percentile) for boys and 165 mmHg (90th percentile) and 170 mmHg (95th percentile) for girls. There was variability in ESBP across age groups. In boys aged 8 to 11 years the P90 was 157 mmHg and the P95 was 160 mmHg, whereas in boys aged 12 to 15 years the P90 was 190 mmHg and the P95 was 195 mmHg. In girls aged 8 to 11 years the P90 was 157 mmHg and the P95 was 160 mmHg, whereas in female children aged 12 to 15 years the P90 was 190 mmHg and the P95 was 195 mmHg. Additionally, boys showed higher ESBP values than girls, except for the 8- to 11-year-old group, and ESBP increased with age. Therefore, the difference is such that percentiles should be used according to age and gender.

2. Discussion

Although the aim of this study was not to perform a screening for HBP or determine the prevalence of HBP—which would have involved measuring BP three times and over different days [3]—we observed that the prevalence of high BP was greater than that reported in previous studies [10]. This fact is especially relevant, since the reference study in Spain [24] and another study performed also in Spain [11] quoted a prevalence of HBP of 3% and a third study reported a 5% prevalence for the 90th percentile [12]. These prevalences are much lower as compared to those found in our study (HBP was found in 22.6% of boys and in 15.22% of girls, although they did not meet the diagnosis criteria for HBP). However, the SME protocol only included two BP measurements taken the same day in a short interval and, as three measurements are necessary, a diagnosis of HBP could not be made.

HBP might be caused by different reasons. The so-called white coat effect that, though it is more frequent in adults and elder people, it also occurs in children [8]. This effect increases the probability of showing HBP. Also, the high incidence of HBP might be due to the presence of other study children in the examination room, which might cause fear, shame, anxiety or restlessness in the subject examined. Finally, the incidence of HBP observed in our study population might be a result of their greater height and weight (the study subjects were basketball players) as compared to the population of other studies [9].

As it occurs in adults, the results obtained in this study demonstrate that ESBP also increases progressively with age in children [13]. Thus, ESBP was lower in younger children: 126.67 mmHg at 8 years and up to 161.89 mmHg at 14 years (Table 2). In girls, ESBP was 132.50 mmHg at 8 years and 153.50 mmHg at 14 years. The same occurs with DBP, which increased with age from 67.92 mmHg at 8 years up to 75.82 mmHg at 14 years. In girls, DBP increased from 70.00 mmHg to 74.25 mmHg (Table 2). Exercise diastolic blood pressure (EDBP) was not considered in this study given the technical difficulties involved in measuring it and the narrow range of values obtained [6].

Given that ESBP is a predictor of cardiovascular disease, it is necessary to determine the EBP values that should be

Please cite this article in press as: Manonelles Marqueta P, et al. Assessing blood pressure in basketball youth players during astrand testing using percentiles. Sci sports (2020), https://doi.org/10.1016/j.scispo.2020.04.001

Table 2 SBP and DBP at rest and during exercise and HR during exercise.

Age	No.		SBP		DBP		ESBP		EDBP		EHR	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
8	24	24	109.27 (±5.10)	110.72 (±5.79)	66.87 (±2.91)	67.29 (±4.60)	126.67 (±6.02)	131.88 (±8.86)	67.92 (±2.69)	70.00 (±4.49)	146.88 (±7.09)	159.38 (±8.89)
9	30	28	108.41 (±3.92)	110.00 (±5.55)	66.41 (±3.23)	67.85 (±4.07)	132.50 (±5.67)	132.50 (±6.41)	68.50 (±3.44)	69.29 (±3.10)	153.33 (±6.4)	165.54 (±7.65)
10	48	30	113.43 (±3.10)	112.33 (±3.14)	69.11 (±2.25)	70.08 (±4.06)	132.50 (±4.37)	133.67 (±4.90)	69.79 (±2.85)	68.33 (±3.07)	156.15 (±5.22)	155.50 (±5.58)
11	53	70	119.10 (±3.26)	118.64 (±3.17)	71.41 (±2.44)	70.50 (±1.81)	139.43 (±4.26)	143.21 (±3.98)	70.94 (±2.75)	70.64 (±2.41)	156.79 (±5.36)	154.21 (±4.39)
12	48	20	122.96 (±4.14)	120.37 (±5.78)	72.44 (±2.64)	71.00 (±2.50)	149.48 (±5.82)	148.25 (±9.24)	71.46 (±2.50)	71.50 (±3.23)	156.25 (±5.21)	155.50 (±11.31)
13	50	31	129.32 (±4.00)	123.46 (±5.46)	75.65 (±2.33)	72.82 (±2.70)	154.40 (±5.72)	150.16 (±6.60)	71.50 (±3.19)	72.26 (±3.75)	154.20 (±3.10)	150.97 (±7.61)
14	45	20	134.22 (±3.99)	125.87 (± 3.99)	75.77 (±2.21)	75.00 (±3.52)	161.89 (±7.65)	153.50 (±9.61)	75.82 (±3.35)	74.25 (±4.31)	146.22 (±5.16)	140.75 (±9 .12)
15	38	20	134.34 (±4.41)	122.38 (±6.70)	73.42 (±2.73)	72.00 (±3.91)	157.24 (±7.57)	147.25 (±9.53)	73.42 (±3.74)	72.25 (±4.05)	142.50 (±6.85)	134.25 (±6.89)

SBP: Systolic Blood Pressure at rest. DBP: Diastolic Blood Pressure at rest. ESBP: Exercise Systolic Blood Pressure. EDBP: Exercise Diastolic Blood Pressure. EHR: Peak Heart Rate during Exercise.

Please cite this article in press as: Manonelles Marqueta P, et al. Assessing blood pressure in basketball youth players during astrand testing using percentiles. Sci sports (2020), https://doi.org/10.1016/j.scispo.2020.04.001

Table 3 Percentiles for Exercise Systolic Blood Pressure (Weighted Average).

Boys							
Percentile	5	10	25	50	75	90	95
Total Group	115.00	120.00	130.00	140.00	160.00	175.00	190.00
8 to 11 yr-old Group	110.00	115.00	120.00	130.00	145.00	157.00	160.00
12 to 15 yr-old Group	120.00	130.00	140.00	150.00	170.00	190.00	195.00
Girls							
Percentile	5	10	25	50	75	90	95
Total Group	110.00	120.00	130.00	140.00	160.00	165.00	170.00
8 to 11 yr-old Group	110.00	115.00	125.00	140.00	150.00	160.00	165.00
12 to 15 yr-old Group	118.00	126.00	140.00	150.00	160.00	170.00	182.00

considered pathological (or at least abnormal) [14]. The term ''hypertensive response to exercise'' (HRE) was coined to refer to abnormal exercise blood pressure and is defined as systolic and/or diastolic BP values exceeding normal limits for age and workload. However, there is no agreement on the values indicating HRE. Regarding younger populations, as in adults, ESBP increases with increased workload [14], and an ESBP > 200 mmHg during maximal exercise is considered an abnormal increase. Although an ESBP reaching 250 mmHg in asymptomatic children and adolescents is not considered dangerous, it is recommended that, for safety purposes during exercise testing, ESBP should not exceed a threshold that cannot be measured [5].

Another factor to consider is that exercise testing was submaximal (Astrand Step) as the heart rate values obtained show (146.88-156.79 beats per minute for boys and 134.25-165.54 beats per minute for girls) (Table 2). Cardiovascular responses to maximal and submaximal exercise in children and adults are different. This difference is associated with the fact that children have lower muscle mass and a smaller heart, and such difference does not rely on the modality of exercise [14]. It is very important to define specific EBP behavior patterns for children. Furthermore, it can be assumed that if testing had been maximum, EBP would also have been higher.

Only the recommendations of the *European Society of Hypertension* establish the pathological criteria for exercise. An ESBP > 200 mmHg with a moderate workload (100 watts) during cycle ergometer testing should be considered abnormal [15]. Apart from some studies performed in healthy and unhealthy adults [4,5], there are no studies defining the upper threshold for ESBP for children using percentiles. Therefore, the contribution of this study is that it provides a percentile chart for assessing SBP response to submaximal exercise in children and adolescents.

The scant studies available suggest that the work performed by the study children was remarkably sub-maximal. The ESBP values obtained in this study emphasize the necessity of defining ESBP threshold values for children and adolescents—especially for those of greater height and weight—in order to reduce the impact of HBP both, in childhood and adulthood [13,14]. The significant differences found between the 8-11 yr age group and the 12-15 yr age group concerning ESBP supports the validity of these percentiles for assessing ESBP. In 8- to 11-yr old boys, an ESBP > 157 mmHg is considered to be high, whereas and an ESBP > 160 mmHg is very high. An ESBP > 190 mmHg is high, whereas an ESBP > 195 mmHg is very high in 12- to 15-yr old boys. In 8- to 11-yr old girls, an ESBP > 160 mmHg is considered to be high, whereas an ESBP > 165 mmHg is very high in children. In 12- to 15-yr old girls, an ESBP > 170 mmHg is high, whereas an ESBP > 182 mmHg is very.

The study has the limitation that it was performed on a very specific population group (very tall 8-15 year-old children); therefore, the results obtained may only be applicable to similar populations. However, a strength of this study is that it reveals a significant prevalence of high BP among children. Another strength is that the method employed in this study can be used in other larger groups, which would require the performance of a new study.

The conclusions obtained in this study are:

- the use of percentiles is useful in assessing systolic blood pressure during Astrand Step Testing in children, which varies with age and gender;
- high exercise blood pressure is found more frequently in boys than in girls;
- in boys, an ESBP > 157 mmHg is considered high, whereas an ESBP > 160 mmHg is very high in 8- to 11-year old children. An ESBP > 190 mmHg is high, whereas an ESBP > 195 mmHg is very high in 12- to 15-year old children.

In girls, an ESBP > 160 mmHg is high, whereas an ESBP >165 mmHg is very high in 8- to 11-year old girls. An ESBP > 170 mmHg is high, whereas an ESBP > 182 mmHg is very high in 12- to 15-year old girls.

Disclosure of interest

The authors declare that they have no competing interest.

References

[1] ESH/ESC, guidelines for the management of arterial hypertension: the Task Force for the Management of Arterial Hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC). Eur Heart J 2013;34:2159—219.

Please cite this article in press as: Manonelles Marqueta P, et al. Assessing blood pressure in basketball youth players during astrand testing using percentiles. Sci sports (2020), https://doi.org/10.1016/j.scispo.2020.04.001

[2] Williams CL, Hayman LL, Daniels SR, Robinson TN, Steinberger J, Paridon S, et al. Cardiovascular health in childhood: A statement for health professionals from the Committee on Atherosclerosis, Hypertension, and Obesity in the young (AHOY) of the Council on Cardiovascular disease in the young, American Heart Association. Circulation 2002;106:143—60.
[3] Falkner B, Daniels SR, Flynn JT, Gidding S, Green LA, Ingelfinger JR, et al. For the National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents. The Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents. Pediatrics 2004;114:555—76.
[4] Miyai N, Arita M, Miyashita K, Morioka I, Shiraishi T, Nishio I. Blood pressure response to heart rate during exercise test and risk of future hypertension. Hypertension 2002;39:761—6.
[5] Washington RL, Bricker JT, Alpert BS, Daniels SR, Deckelbaum RJ, Fisher EA, et al. Guidelines for exercise testing in the pediatric age group. From the Committee on Atherosclerosis and Hypertension in Children, Council on Cardiovascular Disease in the Young, the American Heart Association. Circulation 1994;90:2166—79.
[6] Paridon SM, Alpert BS, Boas SR, Cabrera ME, Caldarera LL, Daniels SR, et al. Clinical stress testing in the pediatric age group: a Statement from the American Heart Association Council on Cardiovascular Disease in the Young, Committee on Atherosclerosis, Hypertension, and Obesity in Youth. Circulation 2006;113:1905—20.
[7] Official Gazette of Aragon n°139:6686-6690; 2000.
[8] Pickering TG, Hall JE, Appel LJ, Falkner BE, Graves J, Hill MN, et al. Subcommittee of professional and public education on the American Heart Association Council on high blood pressure research. Recommendations for blood pressure measurement in humans and experimental animals: Part 1: Blood pressure measurement in humans: A statement for professionals from the Subcommittee of Professional and Public Education of the American Heart Association Council on High Blood Pressure Research. Hypertension 2005;45:142—61.
[9] Factores de riesgo cardiovascular en la infancia y adolescencia en España. Estudio RICARDIN II: Valores de referencia. Grupo Cooperativo Español para el estudio de los factores de riesgo cardiovascular en la infancia y adolescencia. An Esp Pediatr 1995;43:11—7.
[10] Jago R, Drews KL, McMurray RG, Thompson D, Volpe SL, Moe EL, et al. Fatness, fitness, and cardiometabolic risk factors among sixth-grade youth. Med Sci Sports Exerc 2010;42:1502—10.
[11] Díaz Martín JJ, Rey Galán C, Antón Gamero M, Pumarada Prieto M, Gutiérrez Martínez R, Málaga Guerrero S. Presión arterial en la infancia y la adolescencia. Estudio de su relación con variables de crecimiento y maduración. An Esp Pediatr 2000;52:447—52.
[12] Suárez C, Gabriel R. Epidemiología de la hipertensión arterial en España. Cardiovascular Risk Factors 2000;9:239—46.
[13] Turley KR. Cardiovascular responses to exercise in children. Sports Med 1997;24:241—57.
[14] Ahmad F, Kavey RW, Kveselis DA, Gaum WE, Smith FC. Responses of non-obese white children to treadmill exercise. J Pediatr 2001;139:284—90.
[15] O'Brien E, Asmar R, Beilin L, Imai Y, Mallion JM, Mancia G, et al. European Society of Hypertension Working Group on Blood Pressure Monitoring. European Society of Hypertension recommendations for conventional, ambulatory and home blood pressure measurement. J Hypertens 2003;21:821—48.

P. Manonelles Marqueta [a]
J. Álvarez Medina [b]
V. Murillo Lorente [b,*]
[a] *Cátedra de Medicina del Deporte, Universidad Católica de Murcia (UCAM)*
[b] *Facultad Ciencias de la Salud y del Deporte, Universidad de Zaragoza, C/Domingo Miral, s/n, 50009 Zaragoza, Spain*

* Corresponding author.
E-mail address: vmurillo@unizar.es (V. Murillo Lorente)

Received 8 September 2015
Accepted 13 April 2020

Please cite this article in press as: Manonelles Marqueta P, et al. Assessing blood pressure in basketball youth players during astrand testing using percentiles. Sci sports (2020), https://doi.org/10.1016/j.scispo.2020.04.001