**ORIGINAL ARTICLE**
Iran J Allergy Asthma Immunol
December 2014; 13(6):396-403.

# Handgrip Strength Test as a Complementary Tool in Monitoring Asthma in Daily Clinical Practice in Children

**Pedro Ángel Latorre-Román[1], Ana Vanesa Navarro-Martínez[1], Alfonso Mañas-Bastidas[2], and Felipe García-Pinillos[1]**

[1] *Department of Didactic of Corporal Expression, University of Jaen, Jaen, Spain*
[2] *Department of Sports Sciences, University of Granada, Granada, Spain*

*Received: 17 November 2013; Received in revised form: 4 February 2014; Accepted: 16 February 2014*

## ABSTRACT

The aim of this study was to demonstrate that handgrip strength test can discriminate the presence/absence of asthma and between intermittent and moderate persistent asthma in children.

140 children (70 healthy and 70 with asthma) completed the Pediatric Asthma Quality of Life Questionnaire (PAQLQ) and performed the handgrip strength test. Forty-eight hours later, subjects performed spirometry.

The results showed Handgrip strength was significantly lower ($p$<0.001) in children with asthma compared with healthy ones. There were also significant differences ($p$= 0.024) according to the severity of the disease; children with moderate persistent asthma performed worse than children with intermittent asthma. Binary logistic regression analysis and ROC curve analysis revealed that the result in handgrip strength test was a predictive factor for asthma (cut-off at 16.84 kg) and for severity of pathology (cut-off at 15.06 kg).

Handgrip strength was reduced in children with asthma. Handgrip strength was positively associated with lung capacity and quality of life. The fact that the handgrip strength test was able to discriminate between presence/absence of asthma and between intermittent and moderate persistent asthma in children suggested that this test could be used as a complementary tool in the monitoring of asthma in daily clinical practice.

**Keywords:** Asthma; Children; Dynamometry; Quality of life; Rehabilitation

## INTRODUCTION

Children with asthma, especially those with severe clinical forms of the disease, tend to have a sedentary lifestyle and, therefore, a lower aerobic capacity than healthy children.[1] The fear of breathlessness and of exercise-induced asthma (EIA) inhibits the participation of many patients in physical activity and sport,[2] which causes a deterioration of their physical condition[3] and cardiorespiratory capacity in relation with healthy children.[4] Moreover, a sedentary lifestyle causes a higher prevalence of obesity among children with asthma.[5] Muscle strength and peripheral resistance

**Corresponding Author:** Felipe García-Pinillos, MsC (Res); University of Jaen, Campus de Las Lagunillas s/n. D2 Building, Department 142. 23071, Jaén, Spain, Tel: (+34 660) 062 066, E-mail: fegarpi@gmail.com



Published by Tehran University of Medical Sciences (http://ijaai.tums.ac.ir)

is decreased in patients with chronic lung diseases, which seems to contribute to their exercise intolerance.[6] It has been reported that muscular strength is decreased in people with chronic obstructive pulmonary disease (COPD) compared with age-matched healthy peers.[7] However, little is known about muscular strength differences between patients with moderate and severe asthma. In this context, the handgrip strength test is a quick and easy-to-perform muscular fitness test that provides useful information about overall muscular strength, and it could potentially be used in the clinical setting. Some studies have shown that the handgrip strength test can discriminate other pathologies, such as fibromyalgia[8] and COPD in geriatric patients.[9]

Although we know that there exists international standardized tests for the assessment of asthma, because of the complex nature of this disease, its assessment and monitoring seems to be a dynamic process that still requires the contribution of new tools that may facilitate the physicians' daily work. Therefore, this study aimed to determine if the result in the handgrip strength test could be a discriminatory parameter between healthy children and children with asthma, and between different grades of severity of that disease.

## MATERIALS AND METHODS

### Participants

140 children, 70 healthy children (11.44±0.94 years old) and 70 children with asthma (11.14±1.01 years old), diagnosed with asthma by the Ubeda and Jaen Allergy Unit (Andalusia, Spain) were included. All children were randomly selected from eight schools that were also randomly selected from the total of schools of the city of Jaen (random selection was made using a random number generator). All asthmatic children met the following inclusion requirements: i) the disease and its rank of severity were diagnosed according to the criteria of the Global Initiative for Asthma (GINA),[10] ii) the child had been under medical treatment for at least 6 months before the study, iii) the child did not suffer from any other cardiopulmonary disease, musculoskeletal disease and/or intellectual disability. The inclusion criteria for healthy participants were: 1) not to meet the GINA Asthma criteria;[10] 2) the child did not suffer from any other cardiopulmonary disease, musculoskeletal disease and/or intellectual disability. After checking that the participants met those requirements, children with asthma could only be categorized into intermittent and persistent moderate, depending on severity and according to GINA criteria.[10] The parents of the children completed an informed consent form that met the ethical standards of the World Medical Association in the Declaration of Helsinki (2008). The study was approved by the Bioethics Committee of the University of Jaen.

### Materials and Testing

We analyzed the following anthropometric parameters: height (cm), measured with a stadiometer (Seca 222, Hamburg, Germany), body mass (kg), registered with a 634 Seca scale (Hamburg, Germany), and body mass index (BMI), which was calculated by dividing body mass (in kilograms) by the square of the height (in meters).

We used a hand-held dynamometer (TKK 5101 Grip D; Takey, Tokyo, Japan) to measure handgrip strength. Spirometric values (Forced Expiratory Volume in the first second of expiration (FEV1), and Forced Expiratory Volume in the first six seconds of expiration (FEV6) were recorded with a flow meter 6 nSpire Piko (nSpire Health Inc.). This spirometer has been used in previous studies with asthmatic patients,[11] and guarantees the validity of the data and allows for the simple and reliable detection of COPD in primary care.[12] To analyze the quality of life of asthmatic children, we used the PAQLQ in its Spanish version.[13] The differentiation of the severity of asthma was made by taking into account the scale of asthma severity by Masoli et al.[14] and the FEV1 values predicted by Rodríguez et al.[15]

Children were viewed in two different days separated by 48 hours. On the first day, they answered the PAQLQ in the presence of trained researchers, who solved any doubt and guaranteed the anonymity of the responses. Next, body mass was measured and the handgrip strength test was performed, with a hand-held dynamometer with adjustable grip. Subjects had to squeeze gradually and continuously for at least 3 seconds, using the optimal grip span. Each child made 2 attempts with each hand, with the arm outstretched forming an angle of 30° with respect to the trunk, and with the palm of the hand perpendicular to the shoulder line. The maximum score in kilograms for each hand was recorded, and the resulting mean was the score we used in the study. Spirometry was tested on the second day, by the following method; the subject, wearing nose clips and sat in a chair with her/his back straight, had to blow as hard as possible for several seconds (this test was performed complying with the recommendations of the American Thoracic Society (ATS)[16] and the Spanish Society of Pneumology and Thoracic Surgery (SEPAR).[17]

**Statistical Analysis**

Data were analyzed using the statistical program SPSS. version 19.0 by Windows, (SPSS Inc, Chicago, USA), and the significance level was set at $p<0.05$. The data are shown in descriptive statistics of mean and standard deviation. The PAQLQ variables clearly showed a non-normal distribution that did not improve (i.e. did not become normal) after several transformations (e.g., logarithmic and square root transformations) were performed. Consequently, nonparametric statistical tests were used for PAQLQ variables. Comparisons between children with and without asthma, and between children with moderate and severe asthma, for BMI, FEV1, FEV6, and handgrip strength variables, were performed using ANCOVA, using sex and age as covariates. PAQLQ variable differences were analyzed using the Mann-Whitney test. Spearman correlation coefficients were used to examine the relationships of handgrip strength with PAQLQ, BMI, FEV1, and FEV6. The handgrip strength threshold that best discriminates between the presence and absence of asthma, as well as between mild and moderate asthma, was determined by using the ROC curve. Binary logistic regression was performed using as dependent variables the conditions 'healthy' vs 'asthmatic' and 'intermittent asthma' vs 'moderate persistent asthma', and as independent variable 'handgrip strength'.

## RESULTS

No significant differences ($p=0.392$) have been observed in the percentage distribution by sex among groups of asthmatic and healthy children. Table 1 shows the results of the characteristics analyzed in the different groups of subjects. FEV1 results allowed us to classify children according to the Spanish reference FEV1 predicted value for intermittent asthma (FEV1> 80% predicted) and for moderate persistent asthma (FEV1 60-80% predicted).

Handgrip strength was approximately 21.95% lower in the asthma group than in the healthy group ($p<0.001$). Handgrip strength was also lower in the moderate persistent asthma group than in the intermittent asthma group, approximately 13.56% ($p=0.024$) lower.

**Table 1. Age, BMI, FEV1, FEV6, handgrip strength, and PAQLQ in asthmatics vs healthy children and in children with intermittent asthma vs children with moderate persistent asthma**

| | Healthy n=70 Mean (SD) | Asthmatic n=70 Mean (SD) | *p* | Confidence Interval 95% | Asthma intermittent n=28 Mean (SD) | Asthma moderate persistent n=42 Mean (SD) | *p* | Confidence Interval 95% |
|---|---|---|---|---|---|---|---|---|
| Age (years) | 11.14 (1.01) | 11.44 (0.94) | 0.087 | 11.12-11.46 | 11.32 (1.12) | 11.52 (0.80) | 0.259 | 11.23.11.67 |
| Weight (Kg) | 50.69 (12.78) | 44.86 (11.59) | 0.001^ | 45.81-49.83 | 46.55 (10.89) | 43.73 (12.03) | 0.335^ | 42.29-47.79 |
| Height (m) | 1.55 (0.10) | 1.48 (0.09) | <0.001^ | 1.50-1.53 | 1.50 (0.09) | 1.47 (0.09) | 0.088^ | 1.46-1.50 |
| BMI (kg/m$^2$) | 20.74 (3.77) | 20.18 (3.81) | 0.284^ | 19.84-21.09 | 20.55 (4.12) | 19.93 (3.62) | 0.627^ | 19.29-21.09 |
| FEV1 (l) | 1.73 (0.61) | 1.36 (0.43) | <0.001^ | 1.46-1.65 | 1.79 (0.24) | 1.08 (0.27) | <0.001^ | 1.26-1.47 |
| FEV6 (l) | 1.95 (0.65) | 1.83 (1.29) | 0.350^ | 1.74-2.08 | 2.01 (0.53) | 1.70 (1.61) | 0.189^ | 1.59-2.19 |
| Handgrip strength (kg) | 18.58 (5.38) | 14.50 (3.93) | <0.001^ | 15.74-17.41 | 15.78 (4.14) | 13.64 (3.59) | 0.024^ | 13.62-15.44 |
| Limitation of activities | NA | 3.61 (1.30) | NA | - | 3.96 (1.30) | 3.38 (1.25) | 0.038* | 3.32-3.91 |
| Symptoms | NA | 4.05 (1.49) | NA | - | 4.47 (1.46) | 3.76 (1.45) | 0.050* | 3.73-4.40 |
| Emotional function | NA | 4.74 (1.52) | NA | - | 5.31 (1.43) | 4.36 (1.48) | 0.009* | 4.34-5.11 |
| Average PAQLQ | NA | 4.19 (1.37) | NA | - | 4.65 (1.30) | 3.89 (1.34) | 0.011* | 3.89-4.51 |

^ *p* values calculated by ANCOVA age and sex as covariate. **p* values calculated by Mann-Whitney test

NA: not applicable; BMI: body mass index; FEV1: forced expiratory volume in the first second. FEV6: forced expiratory volume in the first six seconds; PAQLQ: pediatric asthma quality of life questionnaire.

**Table 2. Spearman correlations between handgrip strength and PAQLQ, FEV1, FEV6, and BMI in asthmatic children vs healthy children**

| | Asthmatic (n=70) Spearman Correlation | p | Healthy (n=70) Spearman Correlation | p |
|---|---|---|---|---|
| Limitation of activities | 0.278 | 0.020 | NA | NA |
| Symptoms | 0.326 | 0.006 | NA | NA |
| Emotional function | 0.294 | 0.013 | NA | NA |
| Average PAQLQ | 0.325 | 0.006 | NA | NA |
| FEV1 | 0.385 | 0.001 | .526 | <0.001 |
| FEV6 | 0.155 | 0.200 | .559 | <0.001 |
| BMI | 0.437 | <0.001 | .483 | <0.001 |

NA: not applicable; BMI: body mass index; FEV1: forced expiratory volume in the first second, FEV6: forced expiratory volume in the first six seconds; PAQLQ: pediatric asthma quality of life questionnaire.

About the results of the PAQLQ, children with moderate persistent asthma obtained lower scores than children with intermittent asthma on the following dimensions of the questionnaire: activity limitation ($p$ =0.038), symptoms ($p$=0.050), emotional function ($p$=0.009), and PAQLQ average ($p$=0.011).

Table 2 shows Spearman correlations between handgrip strength and PAQLQ, FEV1, FEV6, and BMI, in healthy children and asthmatic children. Regarding children with asthma, handgrip strength shows positive association with the following dimensions; activity limitation ($p$=0.020), symptoms ($p$=0.006), emotional function ($p$=0.013), and average PAQLQ ($p$=0.006). In turn, handgrip strength shows positive association with FEV1 ($p$=0.001) and BMI ($p$<0.001) in children with asthma, and with FEV1 ($p$<0.001), FEV6 ($p$<0.001), and BMI ($p$<0.001) in healthy subjects.

Figure 1 shows the scatter chart between FEV1 and handgrip strength. The binary logistic regression analysis using as dependent variable the 'asthmatic'/'healthy' condition reveals that a high score in the handgrip strength test is a protective factor against asthma (Odds Ratios=0.819, I.C. 95%=0.748-0.896, $p$<0.001). The logistic regression analysis using as dependent variable the 'intermittent asthma'/'moderate persistent asthma' condition shows that a high score in the handgrip strength test is a protective factor against severe forms of asthma (Odds Ratios=0.863, I.C. 95%=0.754-0.987, $p$=0.031).

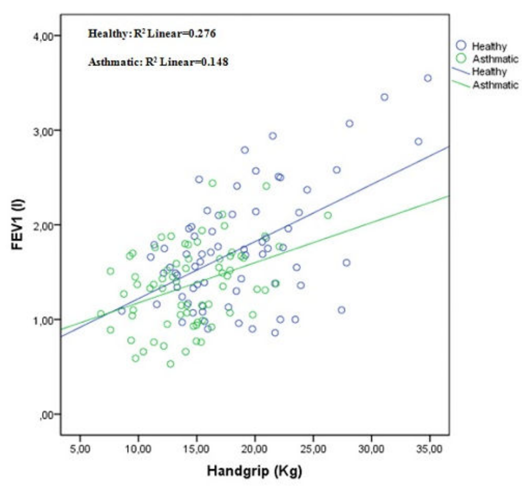


**Figure 1. Scatter chart between FEV1 and results in the handgrip strength test**

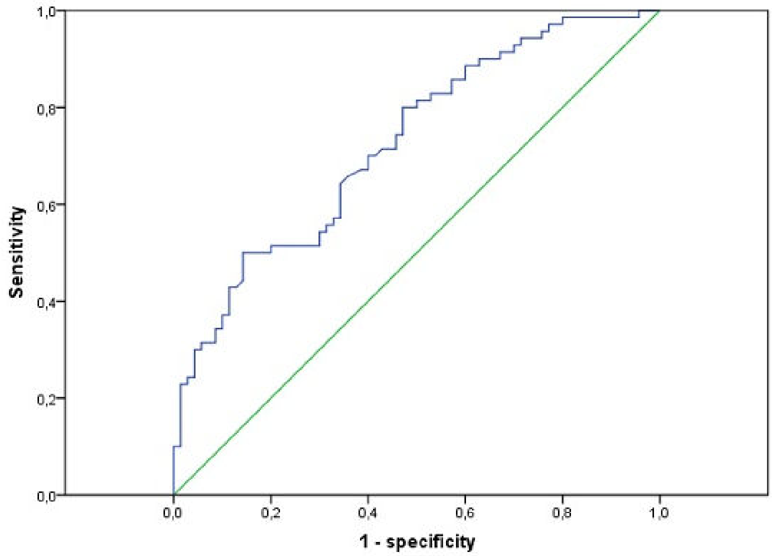


**Figure 2. ROC curve showing the capacity of the handgrip strength test to identify the presence or absence of asthma (healthy children vs children with asthma)**

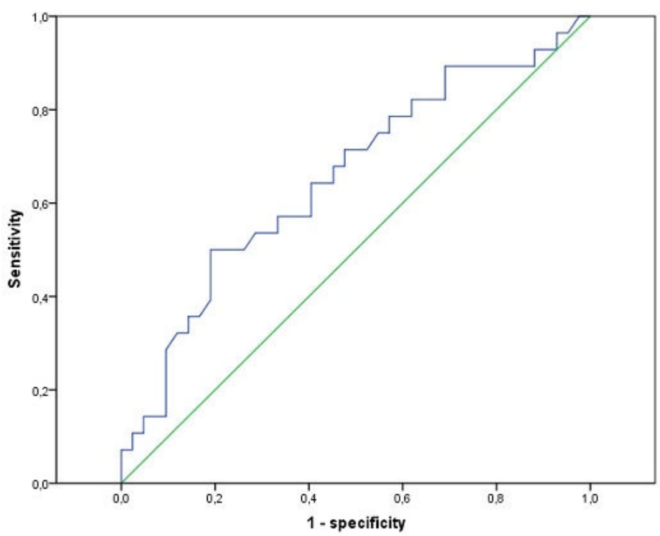


**Figure 3. ROC curve showing the capacity of the handgrip strength test to identify the severity of asthma (children with intermittent asthma vs children with moderate persistent asthma)**

Figure 2 shows the ROC curve of the 'asthmatic'/'healthy' condition predicted by the result in the handgrip strength test (AUC[ASC]=0.726, IC 95%=0.643-0.808, *p*<0.001), showing that the result in the handgrip strength test discriminates between presence and absence of asthma, reaching the cutting point at 16.84 Kg (sensitivity=0.529, 1-specificity=0.300).

Figure 3 shows the ROC curve of asthma severity status predicted by the result in the handgrip strength test (AUC=0.654, IC 95%=0.521-0.787, *p*=0.030), showing that the result in the handgrip strength test discriminates between the two grades of severity of asthma, reaching the cutting point at 15.06 Kg (sensitivity=0.536, 1-specificity=0.333).

## DISCUSSION

The main finding of this study was that handgrip strength was reduced in children with asthma compared with healthy children, and in children with moderate persistent asthma compared with children with intermittent asthma. In turn, handgrip strength was positively associated with quality of life, FEV1, and BMI in children with asthma. The discrimination threshold of handgrip strength among healthy children vs children with asthma was 16.84 kg, and among children with intermittent asthma vs children with moderate persistent asthma was 15.06 kg.

According to normative values for healthy 11-year-old children,[18] which indicate an average of 17.9 kg for males and 16.9 kg for females (a similar performance is obtained in the present study for healthy participants: 18.58 kg), the results registered in this study in the handgrip strength test placed our group of children with asthma (14.50 kg) in the 25$^{th}$ percentile. Thus, handgrip strength could be a physical quality affected by asthma. Yet, there exists some controversy about this in literature, because although some studies[19] obtained lower peaks of muscular and metabolic power in asthmatics compared with healthy subjects, and showed a lower level of handgrip strength (measured with the handgrip strength test) in COPD patients compared with healthy subjects,[20,21] other studies concluded that COPD patients did not show any significant association between handgrip strength and severity of the disease,[22] and between handgrip strength and those patients' ability to realize physical exercise.[23]

Some studies have found that handgrip strength is associated with impaired heart function at rest and during exercise in COPD patients, even adjusting for muscle mass differences. Hence, low handgrip strength may be a marker of impaired cardiac function in COPD patients,[20] and low handgrip strength (as assessed by the handgrip strength test) is associated with multiple chronic diseases and morbidity in men and women.[24] The results of this study showed that the handgrip strength test was a good indicator of the level of overall strength in children with asthma, which added to the already known utilities of this test.

To date, from our knowledge, there is not any study focusing on the association between handgrip strength and BMI in children with asthma. Therefore, this is a novel finding for this study, and the results obtained are consistent with those reported by Jürimäe et al.[25] in prepubertal healthy children, who pointed to body weigth like a limiting factor influencing handgrip strength.

Our data indicated that a high level of handgrip strength was associated with a better quality of life in asthmatic children, since children with moderate persistent asthma, when compared with children with mild intermittent asthma, had a worse quality of life, due to more significant restrictions of activities, symptoms, and emotional function problems, all of which was associated with a low level of handgrip strength. Nonetheless, this statement (that quality of life decreases as the severity of asthma increases) is also somewhat controversial, according to literature, because although some studies found the existence of a negative relationship between those two variables,[26,27] other studies[28] did only find significant restrictions of activities in children suffering from highly severe forms of asthma, and even other studies[29] did not find any relationship at all between severity of asthma and quality of life.

The positive relationship between handgrip strength and quality of life in asthmatic children may be related to high levels of physical activity, as demonstrated by some studies.[30] In this sense, Degens et al.[31] stated that, in patients with moderate COPD, handgrip strength performance did not differ from the values of healthy subjects, provided those patients were physically active.

In our view, the ability to test handgrip strength to discriminate between the presence/absence of asthma, as well as to establish the severity of this condition in children has not yet been sufficiently explored. The statistical approach used, ROC analysis, has a special clinical interest, although the present findings should be replicated in future studies at different ages and ethnic groups. These results suggested that handgrip test could be used as a complementary tool in the monitoring of asthma in daily clinical practice in children.

Future studies should provide age-specific handgrip strength cut-offs for discriminating the presence/absence of asthma and its severity.

Handgrip strength was positively associated with lung capacity and quality of life in children with asthma. The fact that the handgrip strength test was able to discriminate between the presence and absence of asthma and between intermittent asthma and moderate persistent asthma in children made us think that this test could be used as a complementary tool in monitoring asthma. Moreover, the handgrip strength test was relatively inexpensive, and easy to perform, that makes it ideal for clinical practice.

## REFERENCES


1. Kathiresan G. Effect of aerobic training on airflow obstruction, VO2 max, EIB in stable asthmatic children. Health 2010; 2(5):458-64.
2. Welsh L, Kemp JG, Roberts RG. Effects of Physical Conditioning on Children and Adolescents with Asthma. Sports Med 2005; 35(2):127-41.
3. Fanelli A, Cabral ALB, Neder JA, Martins MA, Carvalho CRF. Exercise training on disease control and quality of life in asthmatic children. Med Sci Sports Ex 2007; 39(9):1474-80.
4. Neder JA, Nery LE, Silva AC, Cabral AL, Fernades AL. Short term effects of aerobic training in the clinical management of moderate to severe asthma in children. Thorax 1999; 54(3):202-6.
5. Black MH, Smith N, Porter AH, Jacobsen SJ, Koebnick C. Higher Prevalence of Obesity Among Children With Asthma. Obesity 2012; 20(5):1041–7.
6. Villa F, Castro APBM, Pastorino AC, Santarém JM, Martins MA, Jacob CM, et al. Aerobic capacity and skeletal muscle function in children with asthma. Arch Dis Child 2011; 96(6):554-9.
7. Engelen MP, Schols AM, Does JD, Wouters EF. Skeletal muscle weakness is associated with wasting of extremity fat-free mass but not with airflow obstruction in patients with chronic obstructive pulmonary disease. Am J Clin Nutr 2000; 71(3):733–8.
8. Aparicio VA, Ortega FB, Heredia JM, Carbonell-Baeza A, Sjöström M, Delgado-Fernandez M. Handgrip strength test as a complementary tool in the assessment of fibromyalgia severity in women. Arch Phys Med Rehabil 2011; 92(1):83-8.
9. Frohnhofen H, Hagen O. Handgrip strength measurement as a predictor for successful dry powder inhaler treatment. Z Gerontol Geriatr 2011; 44(4):245-9.
10. Global Initiative for Asthma (GINA). Global strategy for asthma management and prevention 2006. Available from www..ginasthma.org Date last updated 2006..
11. Bossard MK. Monitoring Asthma With Electronic Devices: A Review of the PiKo-1 and PiKo-6 Monitoring Devices. J Asthma Allergy Educ 2011; 2(6): 318-320.
12. Frith P, Crockett J, Beilby J, Marshall D, Attewell R, Ratnanesan A, et al. Simplified COPD screening: validation of the PiKo-6 in primary care. Prim Care Respir J 2011; 20(2):190-8.
13. Tauler E, Vilagut G, Grau G, González A, Sánchez E, Figueras G, et al. The Spanish version of the paediatric asthma quality of life questionnaire (PAQLQ): metric characteristics and equivalence with the original version. Qual Life Res 2001; 10(1):81-91.
14. Masoli M, Fabian D, Holt S, Beasley R, Global Initiative for Asthma (GINA) Program. The global burden of asthma: executive summary of the GINA Dissemination Committee report. Allergy 2004; 59(5):469-78.
15. Morato Rodríguez MD[1], González Pérez-Yarza E, Emparanza Knörr JI, Pérez Legorburu A, Aguirre Conde A, Delgado Rubio A. Valores espirométricos en niños sanos de un área urbana de la Comunidad Autónoma Vasca. An Esp Pediatr 1999; 51(1):17-21.
16. Standardization of spirometry--1987 update. Statement of the American Thoracic Society**.** Am Rev Respir Dis 1987; 136(5):1285-98.
17. Sanchis J, Casan P, Castillo J, González N, Palenciano L, Roca J. Normativa para la espirometría forzada. Recomendaciones SEPAR. Arch Bronconeumol 1989; 25:132-42.
18. Marrodán Serrano MD, Romero Collazos JF, Moreno Romero S, Mesa Santurino MS, Cabañas Armesilla MD, et al. Dinamometría en niños y jóvenes de entre 6 y 18 años: valores de referencia, asociación con tamaño y composición corporal. An Pediatr 2009:70(4):340-8.
19. Counil FP, Varray A, Karila C, Hayot M, Voisin M, Préfaut C. Wingate test performance in children with asthma: aerobic or anaerobic limitation? Med Sci Sports Exerc 1997; 29(4):430-5.
20. Cortopassi F, Divo M, Pinto-Plata V, Celli B. Resting Handgrip force and impaired cardiac function at rest and during exercise in COPD patients. Respir Med 2011; 105(5):748-54.
21. Sirguroh A, Ahmed S. Hand grip strength in patients with chronic obstructive pulmonary disease. Int J Curr Res Rev 2012: 4(19):168-73.
22. Marino DM, Marrara KT, Ike D, De Oliveira AD Jr, Jamami M, Di Lorenzo VA. Study of peripheral muscle strength and severity indexes in individuals with chronic obstructive pulmonary disease. Physiother Res Int 2010; 15(3):135-43.
23. Sherman MF, Road JD, McKenzie DC, Sheel AW. Preserved muscle metaboreflex in chronic obstructive pulmonary disease. Appl Physiol Nutr Metab 2011; 36(6):821-31.
24. Cheung CL, Nguyen US, Au E, Tan KC, Kung AW. Association of Handgrip strength with chronic diseases

and multimorbidity: A cross-sectional study. Age 2013; 35(3):929-941.

25. Jürimäe T, Hurbo T, Jürimäe J. Relationship of handgrip strength with anthropometric and body composition variables in prepubertal children. Homo 2009; 60(3):225-38.
26. Bazán-Riverón GE, Prat-Santaolaria R, Torres-Velázquez LE, Sandoval Navarrete J, Forns Serrallonga D. Asma pediátrica: calidad de vida del paciente relacionada con el impacto familiar. Neumol Cir Torax 2010; 69(2):75-83.
27. Nogueira KT, Silva JR, Lopes CS. Quality of life of asthmatic adolescents: assessment of asthma severity, comorbidity, and life style. J Pediatr 2009; 85(6):523-30.
28. Gomes de Souza P, Couto Sant'anna CB, Pombo M. Quality of life in children with asthma in Rio de Janeiro, Brazil. Indian J Pediatr 2013; 80(7):544-8.
29. Goldbeck L, Koffmane K, Lecheler J, Thiessen K, Fegert JM. Disease severity, mental health, and quality of life of children and adolescents with asthma. Pediatr Pulmonol 2007; 42(1):15-22.
30. Cheng BL, Huang Y, Shu C, Lou XL, Fu Z, Zhao J. A cross-sectional survey of participation of asthmatic children in physical activity. World J Pediatr 2010; 6(3):238-43.
31. Degens H, Sanchez Horneros JM, Heijdra YF, Dekhuijzen PNR, Hopman MT. Skeletal muscle contractility is preserved in COPD patients with normal fat-free mass. Acta Phys Scand 2005; 184(3):235-42.