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The Impact of Moderate Physical Activity on the Resting Metabolic Rate (RMR) in Children with Asthma

Ivona Višekruna[1], Adrijana Miletić Gospić[1], Davor Plavec[1,2], Marcel Lipej[1], Boro Nogalo[1,2], Damir Erceg[1,2,3], Mirjana Turkalj[1,2,3]

[1]Children`s Hospital Srebrnjak, Zagreb, Croatia, [2]Faculty of Medicine, J.J. Strossmayer University of Osijek, Osijek, Croatia, [3]Catholic University of Croatia, Zagreb, Croatia

Correspondence:
ivonavisekruna@hotmail.com
ivisekruna@bolnica-srebrnjak.hr
Tel.: + 385 1 639 1 151
Fax.: + 385 1 639 1 188

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Objective – The objective was to assess whether a two week program of a moderate physical activity affects the resting metabolic rate (RMR) in a group of children with well-controlled asthma. **Materials and methods** – The study included 26 children (14 boys and 12 girls) aged 7-15 years, with well controlled asthma, who participated in Asthma Camp for a period of two weeks, where they had moderate physical activity on a daily basis. Body mass, height and RMR of the participants were measured on the first and last day of the Camp. The RMR assessment was based on a gas exchange measurement. **Results** – A statistically significant difference ($P<0.05$) between the two measurements was found for oxygen uptake (VO_2), expired oxygen content (FeO_2), RMR and % predicted Harris-Benedict, while there was no statistically significant difference for the respiratory minute ventilation, respiratory frequency and heart rate. Average RMR increased from 1244 kcal $\cdot$ day^{-1} to 1535 kcal $\cdot$ day^{-1}. **Conclusion** – Although most of the participants with asthma are in normal body weight range, there is still a significant proportion of overweight/obese participants. Average RMR of children with asthma was lower than expected by the Harris-Benedict equation. Two weeks of structured controlled moderate physical activity led to a significant increase in average RMR in both genders of children with asthma, reaching values higher than the Harris-Benedict estimation. Thereby, regular moderate physical activity should be an essential part of asthma treatment, especially in obese patients, since obesity is one of the most common co-morbidities in asthma.

Introduction

Management of asthma in children aims to achieve complete control of the disease which involves the cessation of symptoms and normalization of lung function to ascertain the most adequate quality of life comparable to healthy children, without limitations in physical activities and sports (1). It is well known that moderate physical activity has a positive effect on health and wellbeing in general. Previous studies have shown that regular moderate physical activity may be useful in the management of asthma (2-4).

Regular physical activity has beneficial effects on lung function, bone and muscular development, cardiovascular fitness, social and psychological wellbeing and general health of young people with asthma (5). Children with asthma often avoid physical activity and have a more sedentary lifestyle (6), which is certainly one of the reasons for obesity being common asthma co-morbidity. As opposed to a sedentary lifestyle, physical activity acts as a bona fide factor on health.

Among other things, it supports the growth and development of the muscular system (lean body mass) and it increases the resting metabolic rate (RMR) (7). RMR is energy expended by the body in a resting condition required to perform normal body functions and maintain homeostasis. It is usually measured by indirect calorimetry, a non-invasive method based on the assessment of energy consumption through gas exchange (oxygen consumption, carbon dioxide production) per unit of time.

Numerous factors cause RMR variations among individuals, primarily gender, age and body composition (8). Some factors stimulate metabolism and cause overestimation of RMR (thermic effect of food, elevated post-exercise oxygen consumption, stimulants and pharmaceuticals) and, therefore, their influence has to be minimized when RMR is measured (9). Since RMR is the largest component of daily energy consumption, stimulation of RMR could help patients with asthma to control their disease better by eliminating one of the most common asthma co-morbidities, such as obesity.

The aim of this study was to assess whether a 2-week moderate aerobic physical activity program can improve RMR in children with asthma.

Materials and Methods

The present interventional study included 26 children (14 boys and 12 girls) aged 7-15 years with mild to moderate well controlled asthma (controlled and partially controlled asthma according to Global Initiative for Asthma guidelines, GINA, 2018) (10), which was the main inclusion criterion of this study. The children participated in Asthma Camp for two weeks, where they were educated about asthma and life with asthma. Asthma Camp is held annually during the second half of June on the island of Lošinj in the Adriatic Sea.

During their stay at the Camp, the children had daily controlled and programmed (by a kinesiologist, physiotherapist, sports medicine specialist and pediatric pulmonologist) moderate physical activity (morning stretching and exercise, swimming, and afternoon recreation and sports games). The experienced expert team was responsible for conducting the training on a daily basis. According to the experts' recommendation, the intensity and type of physical activity was adjusted for each child according to age and individual abilities, resulting in at least 2 hours of an organized mild (40%) to moderate (50%) intensity aerobic training with at least 10% of anaerobic training per day.

During their stay the children were on their regular asthma and allergy treatment. None of the children experienced exacerbation of asthma or had any other health disorders, including any metabolic or endocrinal disorders. The study was approved by the Hospital Ethics Committee and was done in accordance with the Declaration of Helsinki as well as with other relevant international and national legislation. All parents/legal guardians were obliged to sign a written informed consent before the start of Asthma Camp.

Anthropometric Measurements

Body mass and body height were measured in light clothing without shoes, on the combined balance-stadiometer (Seca, Type 710-220, Vogel & Halke Gmbh & Co., Germany). Body weight and body height were measured with an accuracy of 0.1 kg and 0.5 cm, respectively. The weight and the height of the participants were used to calculate the body mass index (BMI). BMI was calculated as weight in kilograms divided by the square of height in meters ($kg \cdot m^{-2}$), and was plotted on the WHO BMI-for-age growth charts (for either girls or boys, 5-19 years) to obtain a percentile range indicating the weight status category.

Measurement of RMR

RMR was measured using the FitMate™ device (Cosmed, Rome, Italy) - a scientifically validated indirect desktop calorimeter. The measurement was performed shortly after the participants had woken up. RMR was measured in a horizontal body position with an oronasal mask on the participant's face. To measure the energy requirements in a resting condition, the participants were required to breathe through the mask for 5 min and 30 s (30 s for self-calibration and 5 min for the measurement). RMR was also presented as % predicted calculated with the Harris-Benedict equation using age, actual body weight, height and gender. The baseline and the final measurements were performed on the first and the last morning of the 2 week-program, respectively.

Statistical Analysis

Statistical analysis was performed using the STATISTICA software package version 12 (StatSoft, Inc. Tulsa, OK, USA). Continuous variables were shown as mean and standard deviation, and categorical variables as absolute and relative frequency (%). Student's t-test and Fisher exact test were used for the comparison of the continuous and categorical variables between the groups, respectively. To compare the variables between the baseline and final measurement, t-test for dependent samples and analysis of variance (ANOVA) for repeated measurements were used. A P-value of less than 0.05 ($P<0.05$) was considered statistically significant.

Results

Demographics and anthropometric parameters of the participants are shown in Table 1. The mean age of all participants was 11 years (7-15 years) with no significant difference between boys and girls. Boys and girls had a comparable body height but boys had a significantly greater body weight (P=0.04) and BMI (P=0.004).

Most of the participants had BMI in a normal weight range (5^{th} to 85^{th} percentiles for age and gender). Four participants (15%) were overweight (85^{th} to 95^{th} percentiles) and four (15%) were obese (>95^{th} percentile), with more overweight/obesity in the boys group than the girls group (P=0.057, Fisher exact test).

Table 1. Age and Anthropometric Parameters of Participants According to Sex

Characteristics	Patients		
	Girls (N=12)	Boys (N=14)	All (N=26)
Age (y)	10.4±1.4	11.9±2.3	11.2±2.0
BW (kg)*	40.1±11.5	52.5±17.0	46.8±15.8
BH (cm)	150.7±14.0	154.8±15.4	152.9±14.6
BMI ($kg \cdot m^{-2}$)†	17.29±2.86	21.24±3.36	19.41±3.67
Underweight (N; %)	1 (8)	0 (0)	1 (4)
Healthy weight (N; %)	10 (83)	7 (50)	17 (65)
Overweight (N; %)	0 (0)	4 (29)	4 (15)
Obese (N; %)	1 (8)	3 (21)	4 (15)

BH=Body height; BMI=Body Mass Index; BW=Body weight; (mean ± standard deviation). Statistically significant differences between sexes (Student's t-test): *T=2.143, P=0.043; †T=3.197, P=0.004.

Table 2. Metabolic Parameters Measured at the Baseline and at the End of the Program According to Sex

Variable	Patients			T	P
	All (N=26)	Boys (N=14)	Girls (N=12)		
$^*VO_2$ (mL · min^{-1})	179 ± 56	180 ± 66	177±46	0.108	0.915
$^†VO_2$ (mL · min^{-1})	221 ± 65	236 ± 72	202±52	1.363	0.185
$^*V_E$ (L · min^{-1})	5.12 ± 1.77	5.07 ± 1.60	5.18±2.02	0.146	0.885
$^†V_E$ (L · min^{-1})	5.73±1.54	5.99±1.50	5.44±1.60	0.896	0.379
*Rf (1 · min^{-1})	15.2±3.3	14.7±3.6	15.7±3.0	0.738	0.468
†Rf (1 · min^{-1})	15.8±4.1	15.4±5.1	16.3±2.6	0.533	0.599
*HR (bpm)	73.3±30.0	82.9±9.6	62.2±41.0	1.842	0.078
†HR (bpm)	82.4±14.8	83.9±8.6	80.6±10.1	0.566	0.576
$^*FeO_2$ (%)	16.81±0.59	16.82±0.61	16.80±0.58	0.098	0.923
$^†FeO_2$ (%)	16.45±0.50	16.38±0.56	16.54±0.43	0.775	0.446
*RMR (kcal · day^{-1})	1244±393	1252±457	1236±323	0.099	0.922
†RMR (kcal · day^{-1})	1535±452	1646±503	1407±362	1.371	0.183
*% Predict	90.35±22.41	83.57±20.84	98.25±22.41	1.730	0.097
†% Predict	110.42±20.6	109.86±21.1	111.08±20.93	0.148	0.883

*Baseline measurement; †Final measurement; VO_2=Oxygen uptake; V_E=Respiratory minute ventilation; Rf=Respiratory frequency; HR=Heart rate; FeO_2=Content of expired oxygen; RMR=Resting Metabolic Rate; % Predict=Calculated with the Harris-Benedict equation (all values are presented as mean ± standard deviation).

Table 3. Representation of Statistically Significant Differences Between the Baseline and the Final Measurement

Variable	All patients (N=26)	T-value	P-value
$^*VO_2$ (mL · min^{-1})	179±56	3.106	0.005
$^†VO_2$ (mL · min^{-1})	221±65		
$^*FeO_2$ (%)	16.81±0.59	3.673	0.001
$^†FeO_2$ (%)	16.45±0.50		
*RMR (kcal ·day^{-1})	1244±393	3.098	0.005
†RMR (kcal · day^{-1})	1535±452		
*% Predict	90.35±22.41	3.146	0.004
†% Predict	110.42±20.6		

*Baseline measurement; †Final measurement; VO_2=Oxygen uptake; FeO_2=Content of expired oxygen; RMR=Resting Metabolic Rate; % Predict=Calculated with the Harris-Benedict equation (all values are presented as mean ± standard deviation; T-test for dependent samples).

Metabolic parameters measured at the baseline and at the end of the 2 week-program are presented in Table 2. There were no significant differences in any metabolic parameters measured between genders (P>0.05 for all, Table 2).

Table 3 shows parameters that significantly improved before and after study intervention (oxygen uptake (VO_2), content of expired oxygen (FeO_2), RMR and % predicted Harris-Benedict equation. Other measured parameters showed no significant differences

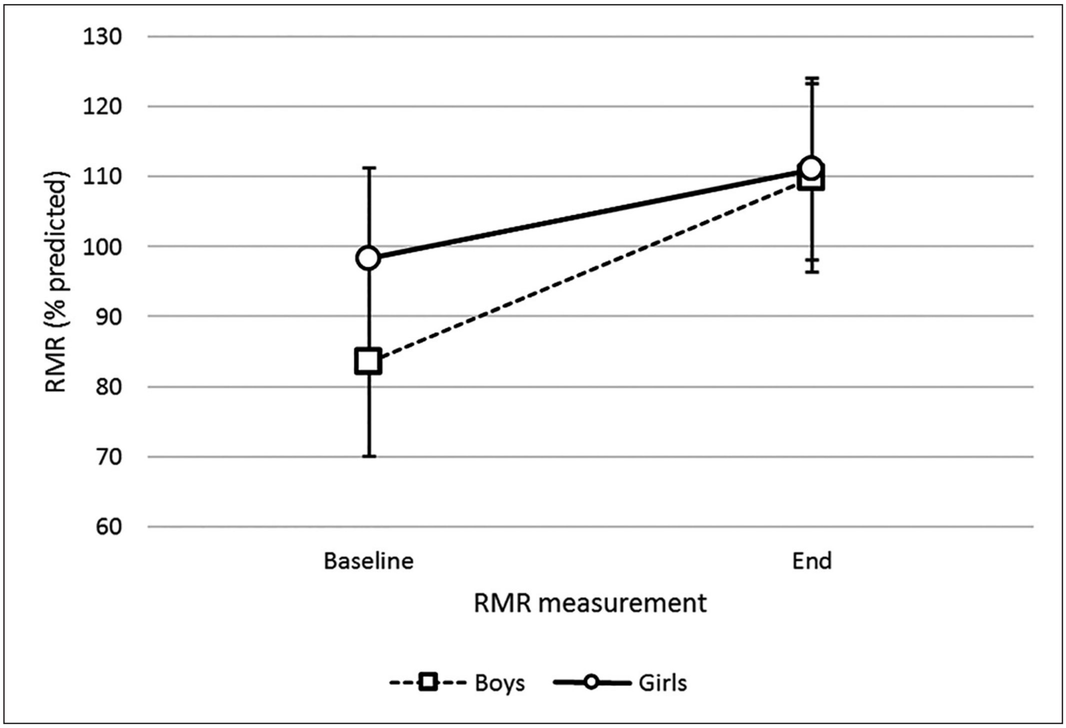

Fig. 1. *The change in Resting Metabolic Rate (RMR) expressed as % of predicted values according to the Harris-Benedict estimation between the baseline and the final measurement according to sex; F=1.109, P=0.303.*

between the baseline and the final measurement. Average RMR increased from 1244 kcal· day^{-1} (or 90.35%) to 1535 kcal · day^{-1} (or 110.42%), reflecting a significant rise in energy consumption at rest (T=3.098, P=0.005; T=3.146, P=0.004; respectively, Table 3). This rise was slightly higher in the boys group than in the girls group but was not statistically significant (F=1.109, P=0.303, ANOVA for repeated measurements, Table 2 and Fig. 1).

Discussion

Average RMR of children with asthma on the initial day of the study was lower than expected by the Harris-Benedict equation. We assume that the sedentary lifestyle of children with asthma accounts for this result (6). In this study, we showed that regular daily moderate physical activity as short as 2 weeks, as a part of the Asthma Camp program, significantly affects RMR of children with mild to moderate well-controlled asthma, presented as a significant increase in energy consumption for the basal metabolism. Other studies have shown that an improved physical fitness in patients with asthma can be associated with reduced symptoms of asthma (4, 11). Our results also suggest that regular physical activity increases RMR, and we assume that in some longer period of time (more than two weeks) this increase in RMR could improve total physical fitness of a child and that it could have a great importance in asthma control in children.

Studies of exercise conditioning in patients with asthma demonstrated improved cardiovascular fitness and quality of life, and in some cases the outcome equals to those achieved by pharmaceutical drugs used to treat asthma (12). The GINA guidelines from

2018 (10) and the European Respiratory Society (13) encourage patients with asthma to be engaged in regular physical activity.

Our participants were involved in regular moderate physical activity, which significantly increased their oxygen consumption (VO_2) and decreased oxygen level in expired air (FeO_2). Because most of the energy in the body is produced aerobically, VO_2 is usually used to determine the amount of energy a participant is consuming. A statistically significant increase in VO_2 and a decrease in FeO_2 values indicate an increase of physical endurance and fitness, resulting in an increase of RMR.

The main predictor of an increased RMR is increased share of muscle tissue in the body due to a high level of metabolic activity (14). On the other hand, an everyday exercise also affects RMR because many physiological variables reach a higher state and remain at that level for a period of time (7). A change in RMR following a single exercise event reaches its peak 2 h post exercise and is detectable to a lesser extent 48 h but not 72 h post exercise (7, 15).

This increase is dependent on intensity, duration, and a mode of exercise. Greer et al. 2015 (16) showed that a steady- state aerobic training did not influence RMR 12 h after exercise. RMR is the largest component of the daily energy budget and therefore, any factor affecting RMR is of great importance for the estimation of daily energy needs and weight maintenance (17).

A rise in RMR is especially important for overweight/obese people in order to reach adequate weight (17). As obesity is one of the most common asthma co-morbidities (18), treatment of asthma, in addition to standard pharmacotherapy, often includes body weight control through a change in dietary habits and introduction of moderate physical activity. Physical activity gives rise to a higher RMR as a result of an increased lean body mass - a metabolically more active tissue and an important predictor of RMR (14).

Some studies have shown that physical activity and changes in diet increase RMR and contribute to the reduction of body weight (17). Our results did not reveal a significant change in body weight - a not-surprising result given the shortness of the intervention period (two weeks). We believe that a longer intervention period could exert significant changes in body weight and composition, especially if a diet intervention is undertaken, too.

Limitations of Study

Although our study showed that regular daily moderate physical activity for a period of only 2 weeks can significantly increase RMR in school age children with asthma, in order to obtain more reliable data further studies are needed taking into account more parameters (the level of usual physical activity, body composition, and dietary habits), which were missing in the present study. A control (sham) group and a larger sample of participants should also be enrolled. In order to determine the actual change in RMR and to distinguish it from the increase in RMR caused by the last exercise event, RMR should be measured repeatedly (e.g. 12, 48 and 72 h after the last exercise event). Finally, participants' dietary regime during the exercise program should be monitored and supervised.

Conclusion

To conclude, the average RMR of participants was lower than predicted by the Harris-Benedict equation. A two week-program of regular daily moderate physical activity gave rise to a significant increase in RMR, with no significant gender-related difference, reaching the value of 110% of predicted by the Harris-Benedict equation. Also it should be noted, since obesity is one of the most common co-morbidity of asthma, encouragement of regular moderate physical activity should be a part of common asthma treatment, especially in children in whom reduction diets with restricted food consumption are not recommended without adequate dietician`s supervision.

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Authors' contributions: Conception and design: MT, IV and AMG; Acquisition, analysis and interpretation of data: DP, ML, MT and IV; Drafting the article: IV and AMG; Revising the article critically for intellectual content: BN, MT, DP and DE; Approved final version of the manuscript: MT.

Conflict of interest: The authors declare that they have no conflict of interest.

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