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Physical Activity: Benefits for Prevention and Treatment of Childhood Obesity

Pinto RM[1-5*], Silva JVP[5,6], Monteiro GMC[5,6], de Resende RC[5,6], Clemente RD[5,6] and de Souza CSB[4,5]

[1]Department of Biology, Replicon Research Center, Catholic University of Goiás, Goiânia, Brazil

[2]Postgraduate Program in Genetics, Catholic University of Goiás, Goiânia, Brazil

[3]Health Sciences PhD Program, Federal University of Goiás, Goiânia, Brazil

[4]Professor of Pediatrics, Federal University of Goiás, Goiânia, Brazil

[5]Academic League of Endocrinology and Nutrology, Federal University of Goiás, Goiânia, Brazil

[6]Graduate Student of Medicine, Federal University of Goiás, Goiânia, Brazil

***Corresponding author**: Pinto RM, Department of Biology, Replicon Research Center, Catholic University of Goiás, Goiânia, Brazil, Tel: +55 62 992637102; E-mail: drarenatamachado@gmail.com

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Abstract

Common obesity, also named exogenous obesity, is a complex disease with multifactorial etiology. In such complex diseases, it is necessary that genetic factors associate with a favorable environment for the phenotype to emerge. After birth, the child´s lifestyle is extremely relevant for determining or preventing the development of obesity.

The practice of Physical Activity (PA) plays a prominent role in the regulation of energy expenditure, since it is the only activity that is totally under conscious control. PA is capable of promoting positive adaptations on childhood obesity and act as aid in its prevention and treatment.

In obese children, the practice of PA leads to: improvement in body composition (reduction of fat mass and increase of lean mass), improvement in cardiorespiratory fitness, strength gain, proprioception, increased caloric expenditure, increased resting metabolic rate, increased tolerance to the use of glucose as an energy substrate, increased insulin sensitivity, improvement in lipid metabolism, and reduction of the inflammatory status.

Keywords: Obesity; Physical activity; Physical exercise; Childhood obesity

Abbreviations:

%BF: Percentage Body Fat; AC: Abdominal Circumference; BMI: Body Mass Index; BW: Body Weight; CL: Cardiac Load; CFV: Cardiac Frequency Variation; CRP: C Reactive Protein; DS: Dyslipidemia; DM: Diabetes Mellitus; GI: Glucose Intolerance; HDL: High Density Lipoprotein; Il-6: Interleukin 6; IN: Insulin; IR: Insulin Resistance; LDL: Low Density Lipoprotein; LPA: Level of Physical Activity; MM: Muscle Mass; PA: Physical Activity; PAI-1: Plasminogen Activator Inhibitor-1; SBP: Systolic Blood Pressure; SNA: Sympathetic Nervous Activity; TC: Total Cholesterol; TG: Triglycerides; TNF-a: Tumor Necrosis Factor-a; WHO: World Health Organization; VO_{2max}: Maximum Volume of Oxygen.

Introduction

Obesity is a disease of energy homeostasis caused by excess of energy supply in relation to the demands of the body. As a consequence, there is an exaggerated energy accumulation in the form of adipose tissue. In adults, the World Health Organization (WHO) defines obesity as a body mass index (BMI) value upper or equal to 30 kg/m^2. In children and adolescents the nutritional status is based on the BMI-for-age 2006 WHO growth standards. Obesity is defined as when the BMI is above 2 standard deviations from the mean for sex and age [1].

BMI has the limitation of not distinguish fat from free-fat mass, which can upper or under estimated obesity. Methods that measure directly the fat mass are more specific and sensible to classify obesity in children, such as densitometry and bioelectrical impedance analysis, as they provide information of body composition [2-4] although they are not routinely used in clinical practice.

Obesity prevalence has increased worldwide, reaching epidemic proportions in many developed and developing countries, being an important cause of morbidity and mortality in the developing world [5]. A report published in 2014 by the Overseas Development Institute of Great Britain [6] shows a general picture of the evolution of obesity around the world in the last 30 years: North America has 70% of the adult population overweight, the largest on the planet; Latin America has a slightly lower index of 63%, which is well above the 30% that was observed in the 1980s.

Specific for childhood obesity a high prevalence is also seen worldwide [7-9]. In the US the obesity prevalence is of 16.9% in 2-19 years-old age group and 8.4% in the 2-5 years-old group [10], with an upward trend of prevalence of children with the severest forms of obesity, with 2% of class 3 obesity prevalence [11].

Determinants of Childhood Obesity: Nature or Nurture?

Common obesity, also named exogenous obesity, is a complex disease with multifactorial etiology. In such complex diseases, it is necessary that genetic factors associate with a favorable environment for the phenotype to emerge [12,13]. Generally, many studies suggest a strong genetic component in human obesity, but pleiotropic genetic syndromes and monogenic diseases account for only 1% of obesity cases [12]. Endocrinological conditions such as Cushing Syndrome and hypothyroidism, are only found in 1 to 3% of obese children [9,14].

Studies with monozygotic twins show that heredity accounts for 40% to 70% of inter-individual variation in cases of common obesity, meaning that 30% to 60% is due to environmental factors [9,12].

The environment can affect human weight since the womb [15,16]. The prenatal factors that interfere with the risk of future obesity include: gestational diabetes mellitus (DM) [16], maternal obesity [17], and smoking during pregnancy [16,18]. Epigenetic changes, like DNA methylation or histone modification in gene regulatory regions are mechanisms that induce these heritable changes in adiposity and explain how these prenatal factors predispose to future obesity [9,19].

After birth, the child´s lifestyle is extremely relevant for determining or preventing the development of obesity. Some habits augment obesity risk, like: formula-feeding instead of breastfeeding, overeating, preference for fast food, omitting breakfast, midnight snacking, playing video games, excess of screen time and lack of exercise [9,20-23].

Physical Activity and Physical Exercise

Physical activity (PA) and physical exercise are terms that describe different concepts. Although they are usually confused with one another, and the terms are sometimes used equivalent [24].

PA is defined as any movement produced by skeletal muscles that result in energy expenditure. Physical activity in daily life can be categorized into occupational, sports, conditioning, household, or other activities. Exercise is a subset of PA that is planned, structured, and repetitive and has a final or an intermediate objective, like the improvement or maintenance of physical fitness. Physical fitness is a set of attributes that are either health or skill related [25].

For children and adolescents, PA include games, sports, transportation, chores, recreation, physical education, or planned exercise, in the context of family, school, and community activities [26].

WHO Recommendations for Physical Activities in Childhood

WHO seeking to improve cardiorespiratory and muscular fitness, bone health, cardiovascular and metabolic health biomarkers recommends that children and youth aged 5-17 should accumulate at least 60 minutes of moderate to vigorous intensity PA daily. Amounts of PA greater than 60 minutes provide additional health benefits and most of the daily PA should be aerobic [27].

Sedentary children should start with small amounts of PA and gradually increase duration, frequency and intensity over time. The concept of accumulation refers to meeting the goal of 60 minutes per day by performing activities in multiple shorter bouts spread throughout the day (e.g. 2 bouts of 30 minutes), then adding together the time spent during each of these [28,29]. Vigorous intensity activities should be incorporated, including those that strengthen muscle and bone, at least 3 times per week [29].

These recommendations are relevant to all healthy children aged 5-17 years, unless specific medical conditions indicate the contrary, irrespective of gender, race, ethnicity, or income level. Whenever possible, children and youth with disabilities should also meet these recommendations. Although, they should work with their health care provider to understand the types and amounts of physical activity appropriate for them considering their disability [30].

Physical Activity and Childhood Obesity

The practice of PA plays a prominent role in the regulation of energy expenditure, since it is the only activity that is totally under conscious control. PA is capable of promoting positive adaptations on childhood obesity and act as aid in its prevention and treatment [9,31].

Obesity promotes a low-grade chronic inflammation state with the release of cytokines such as tumor necrosis factor, C-reactive protein and interleukin 6 [31]. The practice of PA reduces the levels of these inflammatory cytokines [32-34] in addition to increasing cytokines with anti- inflammatory action such as interleukin 10 [31,35] and adiponectin [34,36,37] even without concomitant dietary modification or other lifestyle changes [38].

Regular PA is associated with improvements in aerobic capacity [39-45] strength, muscle growth [46,47] bone mass [35] and weight or body composition [35,41,42,44-49]. Metabolic benefits include the reduction of blood pressure [38,39,48] reduction of glycemia [39,48] leptin [36,37,50-52] and insulin resistance [41,48,49] improvement of the lipid profile with reduction of total cholesterol and increase of HDL cholesterol [31,49,52-55].

Dieting alone often fails to achieve long-term weight maintenance in obese patients, probably because the weight

loss itself leads to a reduction in leptin levels that result in an increase in hunger [38]. The association of PA to diet modifications emerges as an optimal measure to modify the regulation of adipose tissue activity and the systemic target organs responses to it.

Active muscle tissue produces the hormone "Irisin", a 112-amino acid peptide whose main function is to modify white adipose tissue cells into "brite"-brown-in-white-adipocytes whose characteristics resemble those of brown adipose tissue. These cells are rich in mitochondria that increase thermogenesis and energy expenditure they also have a secretory profile of adipokines contrary to that found by white adipose tissue, with secretion of cytokines with anti-inflammatory and improver of insulin sensitivity effects [56,57].

There is an inverse association between PA level and emergence of obesity, especially in the early stages of life [29,32,58]. The magnitude of benefits may vary depending on the type and amount of PA [38,59]. Many studies were designed to access multiple effects that different forms of PA have on childhood weight and health. **Table 1** summarizes the main results.

Table 1: Main metabolic effects of physical exercise on childhood obesity [38,59].

Study	Country	No. (F:M)	Nutritional Status	Type of Exercise	Outcome
Araujo et al. [39]	Brazil	30 (21:9)	Obese	Aerobic plus resistance	↑$V0_{2max}$; ↓GI
Davis et al. [48]	USA	222 (128:94)	Overweight and obese	Aerobic	↓GI; ↓IR; ↓%BF; ↓BMI
Fazelifar et al.	Iran	24 (0:24)	Overweight and obese	Aerobic plus resistance; none	↑Adiponectin
Fazelifar et al. [36]	Iran	24 (0:24)	Overweight and obese	Aerobic plus resistance; none	↓Leptin
Karacabey [50]	Turkey	40 (0:40)	Overweight and obese	Aerobic; none	↓Leptin
Kim et al. [32]	Korea	26 (0:26)	Overweight and obese	Aerobic; none	↑Adiponectin; ↓CRP
Laguna et al. [40]	Spain	437 (227:210)	Overweight and eutrophic	Cycloergometer	↑CFV; ↓BMI
Lai et al. [41]	China	88 (48:40)	Obese	Aerobic	↓CFV; ↓%BF; ↓IG; ↓DS
Lee et al. [42]	USA	45 (0:45)	Obese	Aerobic plus resistance	↓%BF; ↓BMI; ↓BW; ↑MM
Legantis et al. [43]	Greece	48 (23:25)	Overweight and eutrophic	Isometric grip	↑SNA; ↑CL; ↑SBP
Manki et al.	Tunisia	131 (63:68)	Obese	Walking	↑$V0_{2max}$; ↓%BF
Militao et al.	Brazil	34 (17:17)	Overweight and obese	Recreative activities	↓%BF; ↓PAS; ↓TC; ↓TG
Monteiro et al. [33]	Brazil	48 (27:21)	Overweight and obese	Aerobic plus resistance; aerobic	↓IL-6; ↓TNF-a; ↓PAI-1
Park et al. [45]	Korea	29 (15:14)	Overweight and obese	Aerobic plus resistance	↑$V0_{2max}$; ↓AC; ↓BMI
Plonka et al. [51]	Poland	59 (59:0)	Eutrophic	Daily energy expenditure	↓SNA; ↓Leptin
Racil et al. [37]	France	68 (68:0)	Overweight and obese	Aerobic plus resistance; aerobic	↑Adiponectin; ↓Leptin
Schranz et al. [46]	Australia	56 (0:56)	Overweight and obese	Resistance	↑MM; ↓BF; ↓BMI
Vasconcellos et al. [34]	Brazil	20 (6:14)	Overweight and obese	Aerobic; none	↑Adiponectin; ↓Leptin; ↓IL-6
Velez et al. [47]	Spain	28 (13:15)	Overweight and obese	Resistance	↑MM; ↓%BF; ↑BMI
Zorba et al. [49]	Turkey	40 (0:40)	Obese	Aerobic plus resistance	↓%BF; ↓CT; ↓TG; ↓LDL; ↓IN
Woo et al. [52]	Korea	39 (19:20)	Obese and eutrophic	Aerobic	↓SNA; ↓Leptin; ↓TG; ↓LDL

BF: Percentage Body Fat; AC: Abdominal Circumference; BMI: Body Mass Index; BW: Body Weight; CL: Cardiac Load; CFV: Cardiac Frequency Variation; CRP: C Reactive Protein; DS: Dyslipidemia; GI: Glucose Intolerance; HDL: High Density Lipoprotein; IL-6: Interleukin 6; IN: Insulin; IR: Insulin Resistance; LDL: Low Density Lipoprotein; LPA: Level Of Physical Activity; MM: Muscle Mass; PAI-1: Plasminogen Activator Inhibitor-1; SBP: Systolic Blood Pressure

All these benefits make PA practice a fundamental tool to mitigate the damages associated with childhood obesity, considered to be the most important aspect of the approach to prevention and treatment of childhood obesity and its consequences [30,58,59].

Conclusion

The practice of PA is effective for prevention and treatment of childhood obesity. The magnitude of the benefits may vary depending on the type and volume of activity and extends well beyond the effects on body weight.

In obese children, the practice of PA leads to: improvement in body composition (reduction of fat mass and increase of lean mass), improvement in cardiorespiratory fitness, strength gain, proprioception, increased caloric expenditure, increased resting metabolic rate, increased tolerance to the use of glucose as an energy substrate, increased insulin sensitivity, improvement in lipid metabolism, and reduction of the inflammatory status.

It is fundamental for every health professional to be aware of PA benefits for prevention and treatment of childhood obesity. Even though achieving compliance with WHO recommendations can be difficult, it is our duty to simulate and encourage the practice of PA in childhood and adolescence.

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