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Jacobs Journal of Obesity

Perspective Article

Better Understanding of the Exercise- Nutrition – Childhood Obesity Connection A Call for Research

Eliakim A, M.D[1], Nemet D, M.D.,M.H.A[1*]

[1]*Department of Pediatrics, Meir Medical Center, Sackler School of Medicine, Tel Aviv University, Israel*

**Corresponding author: Dr. Dan Nemet M.D., M.H.A., Child Health & Sports Center, Department of Pediatrics, Meir Medical Center, 59 Tchernichovski St. Kfar-Saba, Israel, 44281.Tel: 972-9-7472134; Fax: 972-9-7471303; Email: Dan.nemet@clalit.org.il*

Received: 08-24-2015

Accepted: 09-03-2015

Published: 11-10-2015

Introduction

The mechanisms responsible for the increasing prevalence of childhood obesity are not clearly understood, yet life-style changes associated with increased caloric intake and decreased energy expenditure probably play imperative roles, especially in genetically predisposed populations[1-3]. This indicates that preventive health education and therapeutic programs for childhood obesity require a multi-disciplinary approach that includes life-style/behavioral modification, nutritional education and changes in physical activity patterns [4,5]. Surprisingly however, relatively few studies examined the effect of physical activity and exercise on hunger/satiety and food selection in childhood obesity. This review summarizes our current limited knowledge on nutrition knowledge and preferences in childhood obesity and the effects of brief exercise and prolonged training on appetite and nutritional preferences, and calls for further research in order to improve our understanding of the complicated exercise-appetite-nutrition-obesity cycle.

Nutrition and physical activity knowledge and preferences

Intervention programs for the prevention and treatment of childhood obesity must take into account the nutritional and physical activity knowledge and preferences of children. In light of the fact that the roots of obesity begin early in childhood or infancy, it is interesting that relatively few studies have examined the nutritional and physical activity knowledge of kindergarten and elementary school-aged children. Two older studies in school-children raised concerns regarding the lack of knowledge about food composition; findings noted children's inability to choose foods low in fat and/or saturated fat, and have limited understanding of fiber [6,7]. A third investigation [8] in kindergartners assessed nutritional and physical activity knowledge and preferences using a photo-pair questionnaire developed by Calfas et al [9]. Physical activity knowledge scores were found to be significantly lower than nutrition knowledge scores. However, while food preferences were not consistent with food knowledge in kindergarten children, physical activity knowledge and preference were concordant.

Previous studies in kindergarten children also reported that food preferences were not consistent with their knowledge of dietary guidelines [10] . This suggests that dietary education should not only focus on delivering nutritional information to children; rather it should bring in new ways to implement existing nutritional knowledge in order for children to make healthier food choices and preferences. Nutritional intervention studies in kindergarten children have been associated with positive effects on food selection [11,12]. In the case of promoting physical activity, efforts should probably concentrate on increasing children's knowledge. Since exercise knowledge and preferences correlate positively, promoting exercise knowledge and educating children about the beneficial effects of physical activity and fitness on health may lead to more active lives. Promoting physical activity in kindergartens and schools may result not only in reduction of common childhood diseases (obesity, diabetes, lipid ab-

normalities, asthma etc.), but may be also be associated with increased academic performance, reduction of violence and improved quality of life [13,14].

Interestingly, gender differences were found in the kindergartners' nutritional and physical activity knowledge and preference scores. Nutritional knowledge and preference scores were significantly higher in females, while physical activity preferences were significantly higher in males. This finding indicates that the development of gender-specific favorite interests and inclinations occur as early as the pre-school and kindergarten years. Therefore, health-care providers should concentrate on developing new methods to increase nutritional knowledge in young boys and to improve physical activity preferences and the motivation to exercise in young girls.

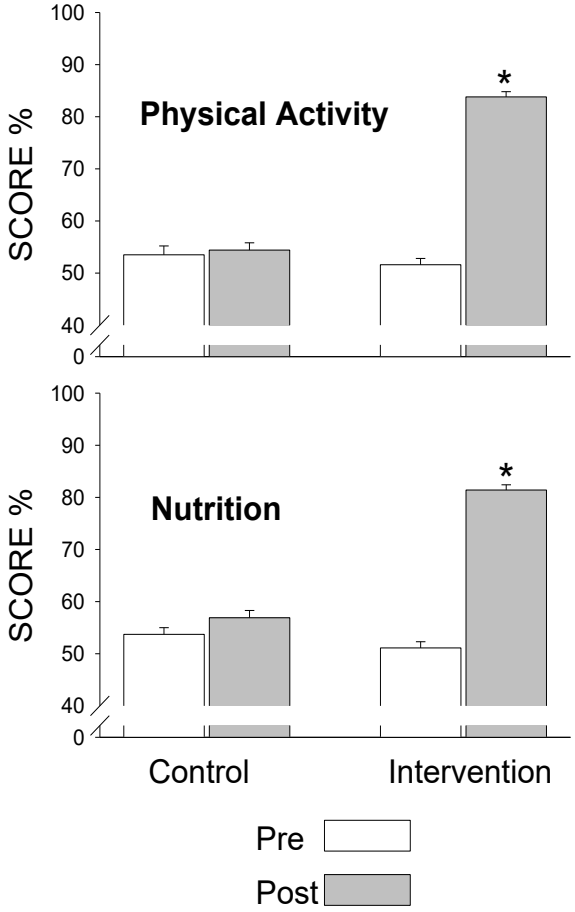

Figure 1. The effect of preschool intervention on physical activity (upper panel) and nutrition (lower panel) knowledge.

Interestingly, we previously demonstrated significantly lower nutrition and physical activity knowledge in Jewish [15] and Arab-Israeli [16] low socio-economic kindergarten children compared to middle-high socio-economic communities [8]. This highlights that the gap in health related knowledge begins as early as the kindergarten years, representing, probably, part of the large environmental contribution to childhood obesity. This suggests that increasing nutritional and physical activity knowledge should be a basic first step in the developments of any childhood obesity intervention program for these unique populations. We found no differences in nutritional and physical activity knowledge and preferences scores between overweight (BMI > 85%ile) and normal weight kindergarten children [8,15,16]. This suggests a gap between knowledge and actual implementation in overweight youth. Therefore, efforts should be made to create environments that will encourage obese pre-school and kindergarten children to eat healthier foods and exercise. Indeed, we previously showed that a combined behavioral-nutrition-physical activity intervention in Jewish and Arab-Israeli low socio-economic children was associated with immediate [15,16] improvement in nutrition and physical activity knowledge (Figure 1) and preferences. Encouragingly, and even more importantly, one year following the intervention, nutrition and physical activity knowledge and preference scores in the Arab-Israeli intervention group participants [17] maintained and were even found to be comparable to high socio-economic class kindergarten children [8]. These changes may hopefully translate to life-long healthier life-style behaviors.

Obesity and exercise related energy intake and food choices

The effects of single and prolonged exercise training on subsequent energy intake and food preferences has gained recent scientific interest. Animal and human adult studies suggest that immediately after strenuous exercise appetite is suppressed and total energy intake is reduced [18,19]. Exercise-induced increases in catecholamines, growth hormone, and free fatty acids acutely increase carbohydrate intake and decrease fat intake [20]. Very few studies examined the effect of physical activity and exercise on hunger/satiety and food selection in childhood obesity. The effects of different types of physical activity (e.g. aerobic, resistance, swimming) on appetite and food choices were recently studied in normal weight and obese pre-pubertal children. The immediate effects of exercise on macronutrient choices were found to differ significantly between normal weight and overweight pre-pubertal children [21]. In normal weight children, resistance-type exercise led to an immediate reduction in total energy intake, moreover, in the normal weight children, all forms of exercise were associated with increased relative consumption of carbohydrate and decreased consumption of fat. In contrast, in the overweight children, all types of exercise increased the relative consumption of protein, and total energy intake normalized to body mass was significantly increased in the obese children following swimming. This suggests that swimming is probably the least favorable choice when trying to achieve the target of negative energy balance and reduction in body weight in obese

children. This finding also demonstrates that if an obese child prefers to swim, a dietary effort must accompany the training to overcome the immediate post swimming increased consumption.

The mechanisms controlling the immediate post-exercise increase in energy and protein intake in obese children are not known. One possible mechanism is the blunted GH and catecholamine responses to exercise found in obese children [22] that may reduce exercise-associated carbohydrate and fat utilization, and as a consequence, increase protein utilization (Figure 2). This may explain why appetite was not suppressed immediately following exercise in the obese children and their need to replenish protein stores by increased protein intake.

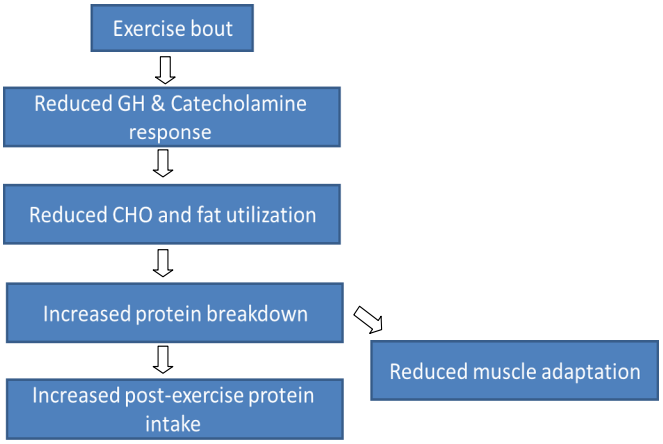

Figure 2. Immediate post-exercise hormonal response, metabolic change and food preferences in obese pre-pubertal children.

In contrast, Prado et al. demonstrated that 30 minutes of exercise at the ventilatory threshold (VT) resulted in a transient anorexic effect in obese adolescent girls [23]. This transient anorexic effect was associated with an increase in peptide YY (PYY), and no change in leptin levels. The authors suggested that aerobic exercise at the VT affects short-term (PYY) but not long-term (leptin) satiety signals in obese adolescent girls. Additional factors like glucagon-like peptide I (GLP-I), cholecystokinin (CCK) and pancreatic peptide [24] were also suggested to play a role in the reduced energy consumption following intense exercise. Other investigators demonstrated that intense late morning exercise bout (e.g. 3 sets of 10 minutes at 70% VO2max) in obese adolescents resulted in reduced energy intake in particularly at dinner time (maximal effect 7 hour following the exercise) [25,26] with no between genders differences [27], and without perceived changes in appetite [26]. In addition, Interestingly, even in the studies that showed reduced energy consumption following an acute exercise bout in obese adolescents [23,27], the protein intake was increased, emphasizing the important role of protein replenishment to post-exercise muscle adaptation in obese youngsters. All together these studies indicate that the type and intensity of exercise, maturity level (pre versus late pubertal), degree of obesity (overweight versus obesity), and the timing of post-exercise energy consumption assessment (immediate versus long-term effects) may all influence the complex balance between energy expenditure, appetite and caloric intake.

Very little is known about the effects of prolonged exercise training on food and macronutrient consumption. It was thought that an increase in physical activity would be accompanied by an increase in appetite [28]. However, aerobic training (10 weeks, twice weekly, 60 minutes of cycling, equivalent to energy expenditure of ~ 3000 kJ per session) resulted in a small decrease in energy intake in obese adolescents (~ 700 kJ/day, [29]) and was associated with a decrease in percent body fat, but not body weight. The authors explained the lack of weight loss by a compensatory reduction of out of intervention spontaneous energy expenditure (the activitystat theory)[30]. In addition, the energy intake response to training was characterized by a very-high inter-individual variability with some individuals increasing and other decreasing their caloric consumption following training. Other studies demonstrated that even if intake increases with exercise training, negative energy balance persists [31]. It is speculated that increased appetite occurs only above a threshold level of physical activity. The activity level that obese children usually perform in exercise intervention programs is probably below this threshold [32].

In summary, it is now known that the effect of exercise on energy balance is not limited to its related energy expenditure but also to its effect on post-exercise appetite, food preferences and subsequent energy intake (Figure 3). Despite a recent increase in the scientific interest in this topic, further studies are needed to clarify the immediate and long-term effects of various forms of exercise, at different volumes and intensities, at different times of the day, and across different ages and maturational status on appetite and food consumption, as well as on the effects of long-term training on the fine balance between physical activity, nutrition and obesity. Better understanding of these relationships will hopefully assist us to break the convoluted chain of exercise-appetite-nutrition and childhood obesity.

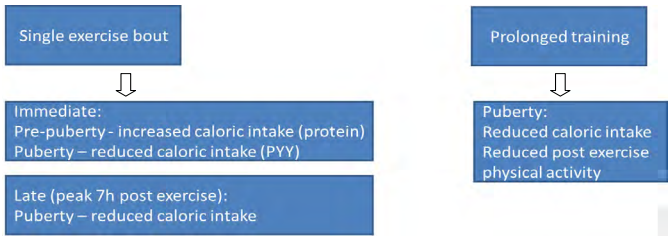

Figure 3. Immediate and late effects of exercise and exercise training on energy consumption in obese children.

Acknowledgement

This was supported by a Grant from the Meir Medical Center Research Authority.

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