Physical Activity and Obesity in Children

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INTRODUCTION

Obesity is one of the most common health problems with increasing prevalence worldwide among people of all ages (Flegal et al., 1998; Seidell, 1999). Obesity during childhood and adolescence is supposed to be an important determinant of whether a subject will become obese as an adult. It has been found that 30% of girls and 10% of boys, who were obese, as children became obese adults (Goran, 2001). Furthermore obesity has been associated with increased risk for hypertension, coronary heart disease and insulin resistance (Power et al., 1997; Gunnell et al., 1998; Teixeira et al., 2001; Must and Strauss, 2002), gall bladder disease, orthopaedic problems, sleep apnea, and several social and psychological problems (Gortmaker et al., 1993; Deckelbaum and Williams, 2001; Must and Strauss, 2002).

Many authorities agree that genetic predisposition; physical inactivity, poor dietary choices, and a toxic environment are primary contributors to the problem of overweight children (Walters et al., 2003). Therefore, the problem of obesity is multifactorial and thought to be a convergence of factors favouring an imbalance between energy consumed and expanded (Hill and Peters, 1998).

Some authors pointed out that genetic factors play a significant role in the pathogenesis of obesity and available evidences suggested four levels of genetic determination of obesity: generic obesity, strong genetic predisposition, slight genetic predisposition, and genetically resistant (Loo and Bouchard, 2003). Likewise, Bar-Or et al. (1998) concluded that genetic make- up is probably responsible for 25- 40%of individual differences in body mass or body fat. However, the increasing prevalence of obesity over the past 30 years suggests that it must be caused by environmental and lifestyle rather than genetic factors (Kesanieme et al., 2001). In fact, complex social and environmental factors contribute to this imbalance (Davison and Birch, 2001; Story et al., 2002), including changing food habits, declining physical activity, and increasingly sedentary lifestyles (US Dep. of Health and Humans Services, 2000).

Thus, obesity is without doubt an important issue nowadays. This is a critical public health concern and makes the prevention of childhood obesity a public health priority for all exercise and public health professionals.

ROLE OF EXERCISE AND PHYSICAL ACTIVITY

To develop effective strategies for obesity prevention, it is critical to determine the relative importance of specific obesity-related risk factors. Patterns of physical activity as well as sedentary living appear to play an important role in long-term weight regulation (Bouchard, 2000). Indeed a secular decrease in energy expenditure is seen to be a major cause of the recent increase in overweight and obesity (Dionne et al., 2000).

Studies reported systematically two main findings. First, physical activity as part of daily life appears to have declined (Caspersen et al., 2000; Telama and Yang, 2000), and television viewing among children and adolescents has increased (Crespo et al., 2001). A report showed that by decreasing a child's TV viewing by 7 hours a week, the risk of obesity is reduced by more than 30% (Crespo et al., 2001). On the other hand, targeting children's patterns of physical activity is especially important given the argument that increasing physical activity in childhood might be essential for the lifetime of regular physical activity (Sallis and Owen, 1999).

Despite some studies addressing the question, the relationship between activity levels and obesity in children remains unclear. It has been difficult to demonstrate convincingly that physical activity plays a significant role in the development of excess body fat during childhood. A child's total energy expenditure (TEE) is the sum of resting metabolic rate, thermogenic effects of food, energy cost of growth, and energy expended as activity, which is the principal remaining contributor of physical activity (Delany, 1998). Therefore, from the theoretical point of view is expected an inverse relationship between activity levels and obesity in children (Rowlands et al., 1999). However, while some studies showed those associations (Boreham et al., 1997; Tell and Vellar, 1998; Rowlands et al., 1999; Dionne et al., 2000) others did not find evidence of such relationship (Armstrong et al., 1991; Grund et al., 2000), mainly when energy expenditure normalized for fat free mass is measured (Goran, 1997). Moreover the

relatively small cohorts of many studies, along with their cross-sectional design, imply that findings should be considered with caution (Thomas et al., 2003). Studies have usually described small to moderate association of physical activity and obesity, to some extent the study of these area depends on the method used to assess activity levels (Rowlands et al., 1997).

It was recommended that when the relationship between physical activity and adiposity is examined, physical activity measures should be more accurate if it is expressed as body movement instead of energy expenditure (Bar-Or and Baranowski, 1994). Despite obese children being usually more inactive, they have higher total energy expenditure than non-obese children (Maffeis et al., 1996). In fact it is unclear whether the influence of physical activity on body fat was due to energy expended or activity time (Goran, 1997). Since children are in continuous state of physical growth, their energy needs in relation to body weight are difficult to study in large epidemiological studies (Crespo et al., 2001). Therefore, it was suggested that it will be worthwhile to measure as many of these factors as possible, such as intensity, metabolic efficiency, overall energy cost, type and time of physical activity (Goran, 1997).

Additionally, physical activity may have varying effects on body fat change at different times during childhood, a fact that may explain some of the variability in previous studies. In fact, it is possible that there are critical periods of susceptibility for the development of obesity (Dietz, 1997). Adiposity rebound refers to certain developmental periods in which there is a rapid increase in adiposity (Rolland- Cachera, 1984). At 5 to 6 years of age, body fat typically reaches its lowest point prior to a critical period of increasing adiposity. This seems to be a particularly important time, with studies showing that children who reach the high levels of adiposity at a younger age have higher risk obesity as adults (Whitaker et al., 1998).

Some earlier studies have found a protective effect of activity on the development of obesity at various time periods during childhood (Moore et al., 1995; O'Loughlin et al., 2000). Recently it was shown a strong protective effect of physical activity on the long-term change in body fat from preschool to early adolescence (Moore et al., 2003). By age 11, the most active children had lower BMI and much less subcutaneous fat (skinfold thickness), than did children in the lower two activity categories. Furthermore, adiposity rebound occurred at a later age for the most active children, perhaps further reducing their risk of obesity later in life.

The autonomic nervous system is a key component in energy balance and fat storage regulation. Exercise seems to have a direct effect in sympathetic nervous system. A lower sympathetic activity was suggested to lead to lower levels of energy expenditure allowing a positive energy balance and weight gain (Peterson et al., 1988). It has been described that, with exercise, the adipose tissue is more sensitive to either the sympa-thetic nervous system or to the rising levels of circulating catecholamines. Either situation would increase lipid mobilization. Nagai and Moritani (2004) showed that physically active children showed greater overall autonomic nervous system activity, in both obese and lean children. This demonstrates that regular physical activity might contribute to the activation of autonomic nervous system (Nagai and Moritani, 2004).

DOSE-RESPONSE RELATIONSHIP

There are two main, complementary strategies in tackling the increasing problem of obesity (Hardeman et al., 2000). The first is to prevent individuals from becoming obese, i.e. to prevent weight gain. The second is to improve the efficacy of weight reduction. Because of several methods to improve weight loss, initial weight loss success is no longer a major problem (Jeffery et al., 2000). However, maintenance of the reduced body weight is much more difficult and a substantial proportion of patients will eventually return towards their initial body weight (McGuire et al., 1999; Hardeman et al., 2000).

Because both weight gain and loss are functions of energy balance, prevention of weight gain could theoretically be achieved by changes in both dietary intake and physical activity (energy expenditure). Weight reduction by increased physical activity without restricted energy intake is only modest (Garrow and Summerbell, 1995). In contrast, many recent reviews have underscored the important role of physical activity in prevention of weight gain (Saris, 1998; Wing, 1999; Jeffery et al., 2000).

The quantification of the amount of physical activity has been the focus of many studies during the last decade. Different attempts have been done to reach a consensus on the relationship between physical activity levels and health outcomes. This was particularly worthy for adults (Saris et al., 2003) and increased concerns against inactivity in children and adolescents raised the

same important question at young ages.

This is an important and timely issue in overall physical activity quantification and especially when it is focused on the dose-response relationship in obese individuals. Generally obese individuals are likely to perceive a given absolute level of physical activity as more intense than younger, fit, less obese individuals (Kesanieme et al., 2001). Relative fat utilization is higher during activity of moderate intensity such as walking, but absolute energy use is higher during vigorous exercise such as running. It has thus been suggested that vigorous exercise results in greater absolute fat oxidation (Glasser, 1995). This may be true for aerobically fit people, but unfit people tend to oxidize less fat at all levels of intensity. Hence, vigorous exercise is not likely to result in as much oxidation in unfit people as activity of more moderate intensity that can be comfortably sustained for longer periods. Obese people are usually unfit, and so moderately intense physical activity should be recommended for them (Egger and Swinburn, 1997). Associated to relative exercise-related intensity, it should be considered the energy expenditure (calories expanded) that occurs during the post exercise period (excess post exercise oxygen consumption -EPOC), which represents the fact that metabolism remains temporarily elevated after exercise ends (Poehlman, 1989). Returning to the pre-exercise metabolic rate can require several minutes following light exercise or several hours following heavy exercise (Poehlman, 1989). But the increase of physical activity and a balanced dose-relationship is also important for lean mass preservation (Boileau et al., 1985). This last aspect seems to be important since significant loss of lean mass in obese subjects were observed after a controlled decrease in energy consumption (Sasaki et al., 1987). If only the controlled decrease in energy consumption strategy is considered, a great loss of FFM might be observed (Fosson et al., 1987) alongwith reductions in the resting metabolic rate.

Additionally children rediscovering the joy and motivation towards physical activity should be an essential component of any treatment plan (Sothern et al.; 1999). To do this, experts recommend that because obese children are limited in their ability to perform weight-bearing activities, such activities should be limited at the start of an intervention (Deforche et al.; 2003) Therefore, beginning with non-competitive games that focus on participation and fun rather than competition and skill as well as aquatic activities should be the focus in the early stages of a program (Hills and Byrne, 1998). Another important issue is the gender-related differences in physical activity. Given that boys are systematically reported to be more active than girls at all ages (Trost et al., 1998; Sallis et al., 2000; Santos et al., 2003), participation in moderate-to-vigorous physical activity is crucial. A recent study showed that significant differences were found in girls, according to the BMI groups, especially in their involvement in MVPA (Mota et al., 2002).

CONCLUSION

Children should be the priority targeting population for prevention and intervention policy. The lack of effective treatment options means that reducing the population burden of obesity will require population based strategies (Swinburn and Egger, 2002). Physical activity is one of the most comprehensive and affordable component as well as a key issue in this strategic plan. Despite some questions still not being completely answered, the physical activity-obesity relationship is under discussion and we have now important findings suggesting an interaction between those two variables either during cross-sectional designed studies and, most importantly in few longitudinal analysis.

REFERENCES

Armstrong, N., Williams, J., Balding, J., Gentle, P. and Kirby, B.: Cardiopulmonary fitness, physical activity patterns, and selected coronary risk factors variables in 11 to 16- years- olds. *Ped. Exerc. Sci.,* **3:** 219-228 (1991).

Bar-Or, O., Foreyt, J. and Bouchard, C.: Etiology and manage-ment of childhood obesity. *Med. Sci. Sports Exerc.,* **30 (1):** 2- 10 (1998).

Bar-Or, O., and Baranowski, T.: Physical activity, adiposity and obesity among adolescents. *Ped. Exerc. Sci.,* **6:** 348- 360 (1994).

Boileau, R., Lohman T., Slaughter M.: Exercise and body composition of children and youth. *Scand. J. Sports. Sci.,* **7 (1):** 17-27 (1985).

Boreham, C.A., Twisk, J. and Savage, M. J.: Physical activity, sports participation and risk factors in adolescents. *Med. Sci. Sports Exerc.,* **29 (6):** 788-793 (1997).

Bouchard, C.: The obesity epidemic:Introduction. pp. 3-20. In: *Physical Activity and Obesity.* C. Bouchard (Ed.), Human Kinetics, Champaign, IL (2000).

Crespo, C.J., Smit, E., Troiano, R. P., Bartlett, S. J., Macera, C. A. and Andersen, R. E.: Television watching, energy intake, and obesity in US children. *Arch. Ped. Adoles. Med.,* **155**: 360- 365 (2001).

Davison, K.K. and Birch, L. L.: Childhood overweight: a contextual model and recommendations for future research. *Obes. Rev.,* **2**: 159- 171 (2001).

Deckelbaum, R.L. and Williams, C. L.: Childhood obesity: the health issue. *Obes. Res.,* **9 (Suppl. 4):** s239-s243 (2001).

Deforche, B., Lefevre, J., De Bourdeaudhuij, I., Hills, A. P., Duquet, W. and Bouckaert, W.: Physical fitness and physical activity in obese and nonobese Flemish youth. *Obes. Res.*, **11 (3):** 434-441 (2003).

Delany, J.P.: Role of energy expenditure in the development of pediatric obesity. *Am. J. Clin. Nutr.*, **68 (Suppl. 4):** s950- s955 (1998).

Dietz, W.H.: Periods of risk in childhood for the development of adult obesity- what do we need to learn? *J. Nutr.*,**127 (Suppl.9):** s1884- s1886 (1997).

Dionne, I., Alméras, N., Bouchard, C. and Tremblay, A.: The association between vigorous physical activities and fat deposition in male adolescents. *Med. Sci. Sports Exerc.*, **32(2):** 92- 392 (2000).

Egger, G., and Swinburn, B.: An "ecological" approach to the obesity pandemic. *BMJ*, **315**: 477-480 (1997).

Flegal, K.M., Carroll, M. D., Kuczmarski, R. J. and Johnson, C. L.: Overweight and obesity in the United States: prevalence and trends, 1960- 1994. *Int. J. Obes. Relat. Metab. Disord.*, **22(1):** 39- 37 (1998).

Fosson, A., Knibbs, J., Bryant-Waugh, R. and Lask, B.: Early onset anorexia nervosa. *Arch. Dis. Child*, **62(2):** 114-118 (1987).

Garrow, J.S., and Summerbell, C. D.: Meta-analysis: effect of exercise, with or without dieting, on the body composition of overweight subjects. *Eur. J. Clin. Nutr.*, **49:** 1- 10 (1995).

Glasser, G. A.: Burning carbohydrate to lose fat. *Sports Med. Digest.*, March: 5 (1995).

Goran, M.I.: Energy expenditure, body composition, and disease risk in children and adolescents. *Proceedings of the Nutrition Society*, **56:** 195- 209 (1997).

Goran, M.I.: Metabolic precursors and effects of obesity in children: a decade of progress, 1990- 1999. *Am. J. Clin. Nutr.*, **73:**158- 171 (2001).

Gortmaker, S.L., Must, A., Perrin, J. M., Sobol, A. M. and Dietz, W. H.: Social and economic consequences of overweight in adolescence and young adulthood. *N. Engl. J. Med.*, **329:** 1008- 1012 (1993).

Grund, A., Dilba, B., Forberger, K., Krause, H., Siewers, M., Rieckert, H. and Muller, M. J.: Relationships between physical activity, physical fitness, muscle strength and nutritional state in 5- to 11-year-old children. *Eur. J. Appl. Physiol.*, **82(5-6):** 425-438 (2000).

Gunnell, D. J., Frankel, S. J., Nanchahal, K. K., Peters, T. J. and Smith, G. D.: Childhood obesity and adult cardiovascular mortality: a 57-y-follow-up study based on the Boyd Orr cohort. *Am. J. Clin. Nutr.*, **67:** 111- 1118 (1998).

Hardeman, W., Griffin, S., Johnston, M., Kinmonth, A. L. and Wareham, N. J.: Interventions to prevent weight gain: a systematic review of psychological models and behaviour change methods. *Int. J. Obes.*, **24:** 131- 143 (2000).

Hill, J.O., and Peters, J. C.: Environmental contributions to the obesity epidemic. *Science*, **280:** 1371- 1374 (1998).

Hills, A. P. and Byrne, N. M.:Exercise prescription for weight management. *Proc. Nur. Soc.*, **57:** 93-103 (1998).

Jeffery, R.W., Epstein, L. H., Wilson, J. T., Drewnowski, A., Stunkard, A. J. and Wing, R. R.: Long- term maintenance of weight loss: current status. *Health Psychol*,. **19:** 5-16 (2000).

Kesanieme, Y.A., Danforth, E., Jensen, M. D., Kopelman, P. G., Lefebvre, P. and Reeder, B. A.: Dose- response issues concerning physical activity and health: an evidence- based symposium. *Med. Sci. Sports Exerc.*, **33(6):** s35- s369 (2001).

Maffeis, C., Zaffanello, M., Pinelli, L. and Schutz, Y.: Total energy expenditure and patterns of activity in 8-10 year old obese and non-obese children. *J. Pediatr. Gastroenterol. Nutr.*, **23:** 256- 261 (1996).

McGuire, M.T., Wing, R. R. and Hill, J. O.: The prevalence of weight loss maintenance among american adults. *Int. J. Obes.*, **23:** 1314-1319 (1999).

Moore, L.L., Gao, D., Bradlee, M. L., Cupples, L. A., Sundarajan-Ramamurti, A., Proctor, M. G., Hood, M. Y., Singer, M. R. and Ellison, R. C.: Does early physical activity predict body fat change throughout childhood? *Prev. Med.*, **37:** 10-17 (2003).

Moore, L.L., Nguyen, U. S., Rothman, K. J., Cupples, L. A. and Ellison, R. C.: Preschool physical activity level and change in body fatness in young children. The Framin-gham Children's Study. *Am. J. Epidemiol.*, **142(9):** 982-988 (1995).

Mota, J., Santos, M.P., Guerra, S., Ribeiro, J.C. and Duarte, J. A.: Differences of daily physical activity levels of children according to body mass index. *Pediatric Exercise Science*, **14(4):** 442-452 (2002).

Must, A. and Strauss, R. S.: Risks and consequences of childhood and adolescent obesity. *Int. J. Obes. Relat. Metab. Disord.*, **23(Suppl 2):** s2-s11 (2002).

Nagai, N., and Moritani, T.: Effect of physical activity on autonomic nervous system function in lean and obese children. *Int. J. Obes.*, **28:** 27-33 (2004).

O'Loughlin, J., Gray-Donald, K., Paradis, G. and Meshefedjian, G.: One-and two- year predictors of excess weight gain among elementary schoolchildren in multiethnic, low-income, inner-city neighbor hoods. *Am. J. Epidemiol.*, **152(8):** 739-746 (2000).

Peterson, H.R., Rothschild, M., Weinberg, C. R., Fell, R. D. McLeish, K. R. and Pfeifer, M. A.: Body fat and the activity of the autonomic nervous system. *N. Engl. J. Med.*, **318:** 1077-1083 (1988).

Poehlman, E. T.: A review: exercise and its influence on resting energy metabolism in man. *Med Sci Sports Exerc*., **21(5):** 515-525 (1989).

Power, C., Lake, J. K. and Cole, T. J.: Measurement and long-term health risks of child and adolescent fatness. *Int. J. Obes. Relat. Metab, Disord.*, **21:** 507-526, (1997).

Rolland-Cachera, M.F., Deheeger, M., Bellisle, F., Sempé, M., Guilloud-Bataille, M. and Patois, E.: Adiposity rebound in children: a simple indicator for predicting obesity. *Am. J. Clin. Nutr.*, **39(1):** 129-135 (1984).

Rowlands, A. V., Eston, R. G. and Ingledew, D. K.: Measure -ment of physical activity in children with particular reference to the use of heart rate and pedometry. *Sports Med.*, **24:** 258-272 (1997).

Rowlands, A.V., Eston, R. G. and Ingledew, D. K.: The relationship between activity levels, aerobic fitness, and body fat in 8-10 year old children. *J. Appl. Physiol.*, **86:** 1428-1435 (1999).

Sallis, J.F. and Owen, N.: *Physical Activity and Behavioural Medicine*. Sage, London (1999).

Sallis, J. F., Prochaska, J. J. and Taylor, W. C.: A review of correlates of physical activity of children and adolescents. *Med. Sci. Sports Exerc.*, **32(5):** 963-975 (2000).

Santos, M.P., Guerra, S., Ribeiro, J. C., Duarte, J. A. and Mota, J.: Age and gender-related physical activity: A descriptive study in children using accelerometry. *J. Sports Med. Phys. Fit.,* **43(1):** 85-89 (2003).

Saris, W.H.M.: Fit, fat and fat free: the metabolic aspects of weight control. *Int. J. Obes.,* **22(Suppl.2):** s15-s21 (1998).

Sasaki, J., Shindo, M., Tanaka, H., Ando, M. and Arakawa, K.: A long-term aerobic exercise program decreases the obesity index and increases the high density lipoprotein cholesterol concentration in obese children. *Int. J. Obes.,* **11(4):** 339-345 (1987).

Seidell, J.C.: Obesity: A growing problem. *Acta Paediatrica,* **88:** 46-50 (1999).

Sothern, M.S., Hunter, S., Suskind, R. M., Brown, R., Udall Jr, J.N. and Blecker, U.: Motivating the obese child to move: the role of structured exercise in pediatric weight management. *South Med. J.,* **92(6):** 577-584 (1999).

Story, M., Neumark-Sztainer, D. and French, S.: Individual and environmental influences on adolescent eating behaviors. *J. Am. Diet Assoc.,* **102(Suppl.3):** s40-s51 (2002).

Swinburn, B. and Egger, G.: Preventive Strategies against weight gain and obesity. *Obes.Rev.,* **3:** 289-301 (2002).

Teixeira, P.J., Sardinha, L.B., Going, S.B. and Lohman, T.G.: Total and regional fat and serum cardiovascular disease risk factors in lean and obese children and adolescents. *Obes. Res.,* **9(8):** 432-442 (2001).

Telama, R., Yang, X.: Decline of physical activity from youth to young adulthood in Finland. *Med. Sci. Sports Exerc.,* **32:** 1617-1622 (2000).

Tell, G.S. and Vellar, O.D.: Physical fitness, physical activity and cardiovascular disease risk factors in adolescents: the Oslo Youth Study. *Prev. Med.,* **17:** 12-24 (1998).

Thomas, N.E., Baker, J. S. and Davies, B.: Established and recently identified coronary heart disease risk factors in young people. The influence of physical activity and physical fitness. *Sports Med.,* **33(9):** 633-650 (2003).

Trost, S.G., Ward, D.S., Moorehead, S.M., Watson, P.D., Riner, W. and Burke, J.R.: Validity of the computer science and applications (CSA) activity monitor in children. *Med. Sci. Sports Exerc.,* **30(4):** 629-633 (1998).

US Department of Health and Humans Services. *Healthy People 2010: Understanding and Improving Health.* 2nd Edn. US Dept. of Health and Humans Services, Washington, DC (2000).

Van Mechelen, W., Twisk, J.W.R., Post, G.B., Snel, J. and Kemper, H.C.G.: Physical activity of young people: The Amsterdam Longitudinal Growth and Health Study. *Med. Sci. Sports Exerc.,* **32(9):** 1610-1616 (2000).

Walters, P.H., Holloman, A., Blomquist, L. and Bollier, M.:Chilhood obesity: Causes and treatment. *ACSM'S Health and Fitness Journal*, **7(1):** 17-22 (2003).

Wing, R.R.: Physical activity in the treatment of the adulthood overweight and obesity: current evidence and research issues. *Med. Sci. Sports Exerc.,* **31:** 547- 552 (1999).

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ABSTRACT Obesity is one of the most common health problems with increasing prevalence worldwide among people of all ages Many authorities agree that genetic predisposition; physical inactivity, poor dietary choices, and a toxic environment are primary contributors to the problem of overweight children. Thus, the problem of obesity is multifactorial and thought to be a convergence of factors favouring an imbalance between energy consumed and expanded. To develop effective strategies for obesity prevention, it is critical to determine the relative importance of specific obesity-related risk factors. Patterns of physical activity as well as sedentary living appear to play an important role in long-term weight regulation. Indeed a secular decrease in energy expenditure is seen to be a major cause of the recent increase in overweight and obesity. This is a critical public health concern and makes the prevention of childhood obesity a public health priority for all exercise and public health professionals. However, despite some studies addressed the question, the relationship between activity levels and obesity in children remained unclear. It has been difficult to demonstrate convincingly that physical activity plays a significant role in the development of excess body fat during childhood. In this paper we will do an overview highlighting the main issues regarding the role of physical activity in youth obesity.

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