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ORIGINAL ARTICLE

Effectiveness of a Multidisciplinary Lifestyle Intervention to Reduce Obesity among Children and Adolescents

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Abstract:

Background: *Now a days unhealthy lifestyle primarily responsible for the dramatic increase obesity among children and adolescents.*

Objective: *The purpose of the study is to see the effects of a multidisciplinary lifestyle intervention to reduce obese children and adolescents. The main outcome was cardiometabolic risk based on the waist-to-height ratio (WHTR) measurement. Secondary outcomes were (1) changes in body composition; (2) adherence to a Mediterranean diet; and (3) physical performance.*

Methods*: The study involved 64 overweight/obese children or adolescents conducted at Dhaka Shishu Hospital from October 2017 to September 2018. The intervention was multidisciplinary including nutrition, exercise, and psychological aspects based on a family-based approach; it was delivered for six months for children and three months for adolescents. Before and after the intervention, several anthropometric measures height, body weight, body mass index (BMI), waist circumference, and body composition, cardiometabolic risk index waist-to-height ratio (WHTR), and dietary habits of the participants and their families were evaluated. In addition, a set of functional motor fitness tests was performed to evaluate physical performance measures.*

Results: *After the intervention both children and adolescents showed a significant reduction in body weight, BMI, waist circumference, fat mass, and WHTR index and an improvement of fat-free mass, adherence to the Mediterranean diet, and physical fitness performance.*

Conclusion: *A short term family-based multidisciplinary approach is effective in ameliorating the health status, dietary habits, and physical performance in children and adolescents.*

Key words: *Lifestyle intervention, obesity, children, adolescents.*

Introduction

The lack of physical activity (PA) or low levels of PA and sedentary habits with overeating/unhealthy eating are the most causes of the increase obesity.[1-4] More specifically, nutrition education efforts should be directed towards children to establish healthy eating habits that will have beneficial effects in adulthood. Perhaps children and adolescent

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populations are those with the most deteriorated Mediterranean diet profile, and thus are worthy of priority attention.[5] Obesity is a multifactorial disease, the product of the complex interaction of genetic, hormonal, physical, nutritional, social, and environmental factors.[6] Overweight and obesity are growing in childhood and adolescence all over the world. In 2014 the World Health Organization (WHO) estimated more than 41 million overweight children under the age of five.[7] European data show that the prevalence of overweight ranged from 18% to 57% among boys and from 18% to 50% among girls; 6-31% of boys and 5-21% of girls are obese.[8] Childhood obesity is a risk factor for adult noncommunicable diseases (NCDs) and represents a health care cost for society.[9] For these reasons childhood obesity is one of the most serious public health problems in our time and a new challenge.[10] Studies show that sedentary behaviors independent of physical activity levels are associated with increased risk of all-cause mortality and psychological problems.[11,12] So, the promotion of physical activity among children and adolescents is considered a strategic way to tackle childhood obesity.[13] Physical activity habits is necessary to develop in early life and persisting into adulthood.[14,15] The prevention and the treatment of childhood obesity is complex and requires a multicomponent approach involving the family and addressing individual and social aspects,[16] focusing not only on physical activity but also on nutrition and enhancing motivation toward a healthy lifestyle.[17-20] As adolescents become more autonomous from their parents they look more to their friends for behavioral and social cues.[21] The family-based approach was defined as the "gold standard" treatment.[22-23] As suggested by Kitzman et al[24] the use of a family-oriented approach to pediatric treatment of obesity can be defined as the active involvement of parents in the treatment of overweight and obesity in children. Family, in particular parents, has been consistently and strongly linked with children's physical activity and sports involvement.[25-29]

Materials and Methods

Total number of 64 children and adolescents subjects with obesity were recruited at Institute of the Dhaka Shishu Hospital, Sher-E-Bangla Nagar, Dhaka from March October 2017 to September 2018. The total sample was divided into two subgroups by age: the children group (n=38, age 3-12 yrs.) and the adolescent group (n=26, age 13-14 yrs.). In the children's group (57.9% male and 42.1% female) there was a mean age of 9.79 ± 1.8 years (min 5-max 12), with no differences for gender, while in the adolescent group (38.5% male and 61.5% female) there was a mean group age of 13.72 ± 0.41 (min 13-max 14), with no differences for gender. Children were evaluated at the Pediatric Clinic of the local hospital and those who met the inclusion criteria were referred to Dhaka Shishu Hospital, Sher-e-Bangla Nagar, Dhaka. At the first visit patients were assessed for the anthropometric values. Inclusion criteria for the enrolment were BMI over 85^0 percentile[30], the absence of contraindications to perform physical exercise, and parents' informed written consent to the lifestyle intervention. The intervention followed the Centro Universitario Ricerca Interdepartmentale Attivita Motorica (C.U.R.I.A.Mo) lifestyle approach for children and adolescents (approved by the Dhaka Shishu (Children) Hospital), a multidisciplinary structured program including the nutritional intervention, the exercise intervention, and the psychological intervention.[31]

All participants followed the three different parts of intervention described later. The 9% of the total sample recruited (4 children) did not start the program because they were still engaged in other sports activities or due to family difficulties in managing the timetable of the activities. Parents' work difficulties were cited as the main barriers to participation. The sample size was calculated based on WHTR endpoint as a main predictor of cardiometabolic risk. A sample size of 74 achieves 89% power to detect a mean of paired differences of 3% with an estimated standard deviation of differences of 8% and with a significance level (alpha) of 0.05 using a two-sided paired t-test. Descriptive analysis in terms of mean, standard deviation, and percentages were computed for the variables investigated. Student's t-test for paired sample was used to compare all assessment measures (anthropometry, diatary habits, and physical activity) before and after intervention (T0-T1). Analyses were limited to participants with baseline data on the different measurements and performed using SPSS, version 22.0.

Results

Anthropometric data at the baseline and after the intervention are reported in Table I for the children's group and in Table II for the adolescent group. In children group after the intervention (T1) data showed a significant decrease in all the measures. BMI (p=0.001), waist circumference (p=0.003), and WHTR index (p<0.001) showed a significant reduction with a small effect size. Regarding body composition (subgroup of 33) data showed a significant decrease with a large effect size of percentage for fat body mass (p <0 .001) and a significant increase in percentage of fat-free mass with a medium effect size (p =0.004) (Table I).

In Adolescents group after the three months intervention adolescents showed a significant decrease in waist circumference (p= 0.012). The subgroup (N=23) assessed with BOD POD showed a reduction of fat body mass percentage (p=0.001) with a medium effect size and an increase of fat-free mass (p=0.004) (Table II).

Table I
Children's anthropometric measure at T0-T1

Anthropometric data	T0	T1	p
BMI (kg/m^2)	26.65±2.41	25.11±2.46	0.001
WC (cm)	90.36±8.46	86.13±7.13	0.003
WTHR (cm)	0.58 ± 0.03	0.54± 0.02	<0.001
FM (kg)	24.01 ± 6.32	20.38 ± 7.30	0.003
FM (%)	40.98± 7.57	35.12 ± 5.41	<0.001
FFM (kg)	35.66 ± 6.23	38.67 ± 7.55	0.015
FFM (%)	61.45 ± 5.40	64.41 ± 5.98	0.004

Data are presented as mean±SD. Statistical significance was considered at p <0.05; BMI = Body mass index; WC = waist circumference; WHTR = waist to height ratio; FM = fat body mass; FFM = fat-free mass.

Table II
Adolescent's anthropometric measure at T0 and T1

Anthropometric data	T0	T1	p
BMI (kg/m^2)	31.93 ±4.31	30.24 ± 4.51	0.032
WC (cm)	105.85 ± 10.63	101.4 ±9.20	0.012
WHTR (cm)	0.65 ± 0.08	0.62 ± 0.07	0.025
FM (kg)	36.74 ± 10.45	33.02 ± 9.33	0.035
FM (%)	40.51 ± 6.82	36.51 ± 7.14	.001
FFM (kg)	51.21 ± 7.17	54.21 ± 8.63	.034
FFM (%)	59.45 ± 7.28	63.12± 6.91	.004

Statistical significance was considered at p<0.05; BMI=body mass index; WC=waist circumference; WHTR=waist to height ratio; FM=fat body mass; FFM=fat-free mass.

Children showed a significant improvement in KIDMED scores with a medium effect size (t=-3.33; p=.002) from T0 =6.73 2.27 to T1=7.93±1.74.

Adolescents showed a significant improvement in KIDMED scores with a large effect size (t=-5,94; p <0.001) from T0 =5.68±2.76 to T1 8.39±2.42.

As reported in Table III, the mean distance walked within six minutes increased (A=37.03±144.03) after three months of exercise, with no statistical difference between two times of evaluation.

Strength values were raised, as expected, in response to the progressive work load proposed during the exercise period. The data showed a significant increase with a medium effect size in ball throw ($p<0.001$ and $p<0.001$). The sprint time of the 30 m test improved significantly, with a large effect size ($p<0.001$). Finally, flexibility improved only the bending test results from the seating position ($p=0.05$) with a small effect size.

As shown in Table IV, maximal oxygen consumption (VO_2 max) increased (A=0.48±4.53) after three months of exercise, with no statistical difference between two tests. In strength values there was a significant increase with a large effect size in every exercise at the isotonic machine (except in a leg press test that presented $p<0.001$), while the flexibility value improved only in bending test from standing position with a small effect size ($p=0.025$).

Table III
Children's physical activity measurement at T0 and T1

Children's physical activity measurement	T0	T1	P
6 MinWT (cm)	678.91 ± 87.5	715.2 ± 154.8	0.105
Ball TA (cm)	4.61 ± 0.75	5.07 ± 0.87	0.002
Ball TB (cm)	4.69 ±1.03	5.56 ± 1.32	0.001
30 m sprint (s)	7.25 ± 0.78	6.36 ± 0.81	<0.001
VB (cm)	-3.12 ± 7.31	-2.21 ±7.81	0.497
HB (cm)	31.68 ± 8.87	33.21 ± 7.87	0.304
Sargent (cm)	23.11 ± 5.42	26.58± 7.02	0.002

Data are presented as mean ± SD. Statistical significance was considered at $p<05$; 6 MinWT = six minutes' walking test; ball TA = medicine ball throw ahead; ball TB = medicine ball throw behind; 30 m sprint = 30 metres' speed test; VB = vertical bending value at sit and reach test, HB = horizontal bending values at sit and reach test; Sargent = Sargent Test Value.

Table IV
Adolescents physical activity measure of the adolescents (13-14) at T0 and T1 of the intervention

Adolescents physical activity measurement	T0	T1	P
VO_2 max (ml/kg/min)	31.20± 7.25	31.32 ± 6.9	0.923
Lat (kg)	35.74 ± 7.85	43.28 ± 8.96	<0.001
Chest (kg)	31.12 ± 7.63	39.21 ±9.36	<0.001
Press (kg)	177.12 ± 51.21	214.91 ± 45.01	<0.001
Lext (kg)	41.21± 11.02	51.93 ± 10.74	.000
VB (cm)	-6.81 ± 7.28	-4.17 ± 6.87	0.037
HB (cm)	30.21 ± 8.87	31.02 ± 9.41	0.617

Data are presented as mean±SD. Statistical significance was considered at $p<0.05$; VO_2 max=maximum rate of oxygen (O_2) consumption; Lat=Lat machine test value; chest=chest press test value; press=leg press test value; Lext=leg extension test value; VB=vertical bending value at sit and reach test, HB=horizontal bending values at sit and reach test.

Discussion

The aim of the present study was to investigate the effects of a multidisciplinary family-based lifestyle intervention to treat overweight/obese children and adolescents. The first results of our structured intervention demon-strate effectiveness in reducing the cardiometabolic risk through a significant reduction of WHTR and changes in body composition. The structured multidisciplinary intervention shows changes in nutritional habits (greater adherence to Mediter-ranean diet) and improvements in physical performance. Many studies[32-35] showed significant positive effects of physical activity in favors of the intervention.

The results of this study seem to be able to show how a multidisciplinary approach based on the family is effective not only in children but also in the adolescent group, where a significant decrease in waist circumference ($p<.001$), a significant reduction of fat body mass percentage ($p< .001$), and a significant decrease in waist circumference ($p<.001$) and in fat body mass percentage ($p<.001$) were observed as well as improvement of the nutritional habits ($p<.001$) and strength parameters. PA attitudes are influenced by individual, social, environmental, and community aspects.[36] Participants with higher perceived peer acceptance, friendship quality, and soccer competence were more likely to continue on with the sport.[37] Family, in particular parents, has been consistently and strongly linked with youth's PA and sport involvement.[25,37-41]

Family influences and friend support can act in improving physical activity habits.[42-44] Children and adolescents are more physically active when in the presence of peers and it is likely that these positive feelings increase the enjoyment and youth motivation to engage in physical activity (PA).[45-47] Decrease of sedentary behavior showed effective in children in the meta analysis presented by Kamath et al[48], and in adolescents in the study by Biddle et al[49]. Interestingly, similar conclusions have been drawn for lifestyle interventions in children to reduce obesity.[50] In its recommendations WHO indicates that children and young people aged 5-17 years should accumulate at least 60 minutes of physical activity every day.[51] The present results confirm that this strategy is effective in ameliorating, in the short term (3-6 months), the health status, the nutrition habits, and the physical performance of children and adolescents. In particular, the present data demonstrate that after the intervention the participants significantly reduced BMI, WC, WHTR, and fat mass and improved fat-free mass, adherence to the Mediterranean diet, and physical fitness.

At baseline, the participants in the study did not follow this recommendation. As shown previously in Tables 3 and 4 improvements in (1) dynamic strength; (2) cardiorespiratory efficiency; (3) the speed of the children, and (4) flexibility were observed. In addition, to train aerobic capacity and flexibility resistance training was also included in the exercise intervention. In adolescents cardiovascular activity was presented using ergometers and with gradually increasing work intensity (5% every two weeks) from 50% up to 70-80% of heart rate reserve[52] combined with free loads and work at isotonic machines with a gradual increase from 55% up to 70-80% of 1 repetition maximum (RM), according to an adolescent's basal fitness level. After three months of exercise, data showed that strength values increased, as expected, in response to gradually augmented load used during exercise periods. In particular, relevant changes in the dynamic strength of the upper limbs and trunk and lower extremity strength were observed, with a medium and large effect size.

In adolescents, we tested the effects of the intervention on VO_2 max and did not observe significant changes. As regards flexibility, the existing studies confirm a role for genetic influences on the individual differences but estimates vary widely. 18-55% of the variation in flexibility (as measured by the sit and reach test) in children and young adults could be explained by genetic influences.[53]

Conclusion

Multidisciplinary lifestyle intervention based on a family-based approach, demonstrating that such kind of approach allows obtaining positive results in lifestyle habits changing in not only children but also adolescents groups with obesity, after a short period (3 to 6 months).

References

1. Centers for Disease Control and Prevention C. Over weight and obesity: causes and consequences. 2009.

2. Tremblay MS, LeBlanc AG, Kho ME. Systematic review of sedentary behaviour and health indicators in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity* 2011;**8**:98.

3. Carlin A, Murphy MH, Gallagher AM. Do interventions to increase walking work? a systematic review of interventions in children and adolescents. *Sports Medicine* 2016;**46**:515-30.

4. Serra-Majem L Bautista-Casta˜no.Etiology of obesity: two 'key issues' and other emerging factors. *Nutrition Hospitalaria* 2013;**28**:32-43.

5. Serra Majem L, Ngo de la Cruz J. Que´ es la Dieta Mediterra´nea. *Barcelona: Nexus Ediciones*, 2002;1-221.

6. Chan R S M, Woo J. Prevention of overweight and obesity: how effective is the current public health approach. *International Journal of Environmental Research and Public Health* 2010;**7**:765-83.

7. UNICEF, WHO, World Bank. Level and trends in child malnutrition: UNICEF-WHO-World Bank joint child malnutrition estimates. Washington, USA: 2015.

8. Wijnhoven T, van Raaij J, Spinelli A. WHO European childhood obesity surveillance initiative: body mass index and level of overweight among 6-9-year-old children from school year 2007/2008 to school year 2009/2010. *Bio Medical Central Public Health* 2014:806.

9. Park M H, Falconer C, Viner R M, Kinra S. The impact of childhood obesity on morbidity and mortality in adulthood: a systematic review. *Obesity Reviews* 2012;**13**:985-1000.

10. WHO. Global strategy on diet, physical activity and health. Why does childhood overweight an obesity matter? http://www.who.int/dietphysicalactivity/childhood_consequences/en.

11. Katzmarzyk PT, Church TS, Craig CL, Bouchard C. Sitting time and mortality from all causes, cardiovascular disease, and cancer. *Medicine and Science in Sports and Exercise* 2009;**41**:998-1005.

12. Owen N, Bauman A, Brown W. Too much sitting: a novel and important predictor of chronic disease risk? *British Journal of Sports Medicine* 2009;**43**:81-83.

13. Must A, Tybor D J. Physical activity and sedentary behavior: a review of longitudinal studies of weight and adiposity in youth. *International Journal of Obesity* 2005;**29**:S84-S96.

14. Twisk J W, Kemper H C, Van Mechelen W. Tracking of activity and fitness and the relationship with cardiovascular disease risk factors. *Medicine & Science in Sports & Exercise* 2000;**32**:1455-61.

15. Taylor W C, Blair S N, Cummings S S, Wun C C, Malina R M. Childhood and adolescent physical activity patterns and adult physical activity. *Medicine and Science in Sports and Exercise* 1999;**31**:118-23.

16. Rajmil L, Bel J, Clofent R, Cabezas C, Castell C, Espallargues M. Clinical interventions in overweight and obesity: a systematic literature review 2009-2014. *Anales de Pediatria* 2016.

17. Ling J, Robbins L B, Wen F. Interventions to prevent and manage overweight or obesity in preschool children: a systematic review. *International Journal of Nursing Studies* 2016;**53**:270-89.

18. Avery A, Pallister C, Allan J, Stubbs J,Lavin J. An initial evaluation of a family-based approach to weight management in adolescents attending a community weight management group. *Journal of Human Nutrition and Dietetics* 2012;**25**:469-76.

19. Pinard CA, Hart MH, Hodgkins Y, Serrano EL, McFerren MM, Estabrooks P A. Smart choices for healthy families: A pilot study for the treatment of childhood obesity in low-income families. *Health Education and Behavior* 2012;**39**:433-45.

20. Altman M, Wilfley D E. Evidence update on the treatment of overweight and obesity in children and adolescents. *Journal of Clinical Child and Adolescent Psychology* 2015;**44**:521-37.

21. Gifford-Smith M, Dodge KA, Dishion TJ, McCord J. Peer influence in children and adoelscents: crossing the bridge from development to interven tion science. *J Ab norm Child Psych* 2005;**33**:255-65.

22. Skelton JA, Buehler C, Irby MB, Grzywacz JG. Where are family theories in family-based obesity treatment: conceptualizing the study of families in pediatric weight management. *International Journal of Obesity* 2012;**36**:891-900.

23. Barlow S E. Expert committee recommendations regarding the prevention, assessment, and treatment of child and adolescent overweight and obesity: summary report. *Pediatrics* 2007;**120**: S164-S92.

24. Kitzmann KM, Beech BM. Family-based interventions for pediatric obesity: methodological and conceptual challenges from family psychology. *Journal of Family Psychology* 2006;**20**:175-89.

25. Fredricks JA, Eccles JS. Parental influences on youth involvement in sport. In: Weiss MR, editor.

Developmental sport and exercise psychology: a lifespan perspective, Morgantown. *WV: Fitness Information Technology*; 2004:145-64.

26. Van der Horst K, Chin A, Paw MJM, Twisk JWR, van Mechelen W. A brief review on correlates of physical activity and sedentariness in youth. *Med Sci Sports Exerc* 2007;**39**:1241-50.

27. Arnon S, Shamai S, Ilatov Z. Socialization agents and activities of young adolescents. *Adolescence* 2008;**43**:373-97.

28. Fawcett LM, Garton AF, Dandy J. Role of motivation, self-efficacy and parent support in adolescent structured leisure activity participation. *Australian J Psychol* 2009;**61**:175-82.

29. Wenthe PJ, Janz KF, Levy SM. Gender similarities and differences in factors associated with adolescent moderate-vigorous physical activity. *Pediatr Exerc Sci* 2009; **21**:291-304.

30. Cacciari E, Milani S, Balsamo A, et al. Italian cross-sectional growth charts for height, weight and BMI (2 to 20 yr). *Journal of Endocrinological Investigation* 2006;**29**:581-93.

31. Piana N, Battistini D, Urbani L. Multidisciplinary lifestyle intervention in the obese: its impact on patients' perception of the disease, food and physical exercise. *Nutrition, Metabolism and Cardiovascular Diseases* 2013;**23**:337-43.

32. de Meij JS, Chinapaw MJ, van Stralen MM. Effectiveness of JUMP-in, a Dutch primary school-based community intervention aimed at the promotion of physical activity. *Br J Sports Med* 2010;**33**.

33. Angelopoulos PD, Milionis HJ, Grammatikaki E. Changes in BMI and blood pressure after a school based intervention: The CHILDREN study. *Eur J Public Health* 2009;**19**:319-25.

34. McNeil DA, Wilson BN, Siever JE. Connecting Children to Recreational Activities: Results of a Cluster Randomized Trial. *Am J of Health Prom* 2009; **23**:376-87.

35. Simon C, Schweitzer B, Oujaa M. Successful overweight prevention in adolescents by increasing physical activity: A 4-year randomized controlled intervention. *Int J of Obesity* 2008;**32**:1489-98.

36. Spence JC, Lee R E. Toward a comprehensive model of physical activity. *Psychology of Sport and Exercise* 2003;**4**:7-24.

37. Ullrich-French S, Smith AL. Social and motivational predictors of continued youth sport participation. *Psychol Sport Exerc* 2009;**10**:87-95.

38. Van der Horst K, Chin A, Paw MJM, Twisk JWR, van Mechelen W. A brief review on correlates of physical activity and sedentariness in youth. *Med Sci Sports Exerc* 2007;**39**:1241-50.

39. Arnon S, Shamai S, Ilatov Z. Socialization agents and activities of young adolescents. *Adolescence* 2008;**43**:373-97.

40. Fawcett LM, Garton AF, Dandy J. Role of motivation, self-efficacy and parent support in adolescent structured leisure activity participation. *Australian J Psychol* 2009;**61**:175-82.

41. Wenthe PJ, Janz KF, Levy SM. Gender similarities and differences in factors associated with adolescent moderate-vigorous physical activity. *Pediatr Exerc Sci* 2009;**21**:291-304.

42. Craggs C, Corder K, Van Sluijs E M F, Griffin S J. Determinants of change in physical activity in children and adolescents: A systematic review. *American Journal of Preventive Medicine* 2011;**40**: 645-58.

43. van der Horst K, Paw M G, Twisk J M, van Mechelen W R, A brief review on correlates of physical activity and sedentariness in youth. *Medicine & Science in Sports Exercise* 2007;**39**:1241-50.

44. Brustad R J. Attraction to Physical Activity in Urban Schoolchildren: Parental Socialization and Gender Influences. *Research Quarterly for Exercise and Sport* 1996;**67**:316-23.

45. Salvy S J, Bowker J C, Germeroth L, Barkley J. Influence of peers and friends on overweight/obese youths' physical activity. *Exercise and Sport Sciences Reviews* 2012;**40**:127-32.

46. Salvy S J, Roemmich J N, Bowker J C, Romero N D, Stadler P J, Epstein L H. Effect of peers and friends on youth physical activity and motivation to be physically active. *Journal of Pediatric Psychology* 2009;**34**:217-25.

47. Duncan S C, Duncan T E, Strycker L A, Chaumeton N R. A cohort-sequential latent growth model of physical activity from ages 12 to 17 years. *Annals of Behavioral Medicine* 2007; **33**:80-89.

48. Kamath CC, Vickers KS, Ehrlich A, McGovern L, Johnson J, Singhal V, *et al*. Clinical review: behavioral interventions to prevent childhood

obesity: a systema tic review and metaanalyses of randomized trials. *J Clin Endocrinol Metab* 2008; **93**:4606-15.

49. Biddle SJ, O'Connell SRE. Braithwaite Sedentary behaviour interventions in young people: a meta analysis. Br,*J Sports Med* 2011;**45**:937-42.

50. Connelly JB, Duaso MJ, Butler G. A systematic review of controlled trials of interventions to prevent childhood obesity and overweight: a realistic synthesis of the evidence. *Public Health* 2007;**121**: 510-17.

51. World Health Organization (WHO). Physical activity fact sheet. 2015. http://www.who.int/mediacentre/factsheets/fs385/en/. Accessed 03 May 2015.

52. Karvonen MJ, Kentala E, Mustala O. The effects of training on heart rate; a longitudinal study. *Annales Medicinae Experimentalis et Biologiae Fenniae* 1957;**35**:307-15.

53. Chatterjee S., Das N. Physical and motor fitness in twins. *Japanese Journal of Physiology* 1995;**45**:519-34.