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Physical Fitness and Physical Activity in Children and Adolescences with Type 2 Diabetes

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Abstract: *The global obesity epidemic has raised concerns about the risk of Type 2 diabetes (T2DM) in childhood. The purpose of this study to compare motor performance and cardiorespiratory function in children and adolescences with type 2 diabetes against an age-matched control group.*

Methods: *One hundred and two children and adolescences with type 2 diabetes and 102 non diabetic peers aged 8-18 years. Skinfold thickness, and body mass index were evaluated. Physical fitness was assessed with the Eurofit Test Battery on motor performances and cardiorespiratory fitness (VO2max), while physical activity level was assessed by a modified version of the Baecke Questionnaire.*

Results*: Younger boys and girls with diabetes were found to have a reduction in speed of upper limb movement, abdominal muscle strength, and upper body strength when compared to controls. Running speed and VO2max were reduced in only younger girls. Static strength of the hand was reduced in only younger boys. Older boys and girls with diabetes had a reduction in speed of upper limb movement, abdominal muscle strength, upper body strength and VO2max compared to controls.*

Conclusions*: Younger and older children and adolescences with diabetes have reduced fitness parameters. Effort should be made to improve physical fitness by encouraging adherence to physical activity as part of treatment and care of children and adolescents with type 2 diabetes*

Key Words: *Type 2 diabetes, Children, Adolescences, Physical fitness.*

I. Introduction

Diabetes is the third most common chronic disease of childhood [1]. Type 1 or autoimmune diabetes accounts for about 99% of cases [2] and over the past 30 years it has been recognized that not all diabetes in childhood is classified as type 1. Type 2 diabetes has been emerging as a public health problem in children and adolescents over the last 2 decades and has been becoming an important public health concern throughout the world[3]. Depending on the population studies, T2DM now represents 8–45% of all new cases of diabetes reported among children and adolescents. Some children as young as 8 years old being affected [4-5].

Until recently, the majority of cases of diabetes mellitus among children and adolescents were immune-mediated type 1a diabetes. Obesity has led to a dramatic increase in the incidence of type 2 diabetes (T2DM) among children and adolescents over the past 2 decades. Obesity is strongly associated with insulin resistance, which, when coupled with relative insulin deficiency, leads to the development of T2DM. Children and adolescents with T2DM may experience the micro vascular and macro vascular complications of this disease at younger ages than individuals who develop diabetes in adulthood. These include atherosclerotic cardiovascular disease, stroke, myocardial infarction, and sudden death; renal insufficiency and chronic renal failure; limb-threatening neuropathy and vasculopathy; and retinopathy leading to blindness [6-9].

The prevalence of T2DM varies among different child and adolescent populations; it was first described in Pima Indian adolescents of Arizona, USA, in 1979[10]. Among Japanese school children, the prevalence of type 2 diabetes has increased in 20 years, from 2 to 76 per 100,000 individuals [11]. It was subsequently reported among various minority non-Caucasian ethnic groups, for example in the USA, Canada, Australia, New Zealand and among children from Japan, Hong Kong, Libya and Bangladesh as well as in Asian and Arab children in the UK[12,13]. The phenotypic constellation of type 2 diabetes (hyperglycemia, obesity, dyslipidemia, and insulin resistance) is similar in adults and children. The constellation of clinical characteristics in children with type 2 diabetes suggests that the initial abnormality is impaired insulin action, compounded later with B cell failure [13-16].

Physical fitness is generally defined as " the ability to perform daily tasks without fatigue" (WHO, [17]) and with enough energy remaining to enjoy spending free time, as well as to resolve unusual situations of sudden and unforeseen emergency (Council of Europe, [18]). Physical fitness and regular physical activity are key factors in health and well being of all individuals. Nevertheless, both physical activity and physical fitness are strong predictors of risk of death [19-21].

There is a significant relationship between physical activity and physical fitness in children and adolescence with diabetes. Several studies have emphasized the importance of increased physical activity in the prevention of Type 2 diabetes [22, 23] and in improving glycemic control in established Type 2 diabetes [24, 25]. For 15 For 15 years, the Diabetes Centre Aintree Hospitals, Liverpool suggested that increase in

physical activity in diabetic patients (both Type 1 and Type 2) will improve physical fitness, hence long-term cardiovascular risk will be reduced and glycemic control is likely to improve [26,27].

Few data are available regarding investigation of physical fitness in type 2 diabetes, especially in children and adolescents. The aim of this study was to compare motor performance, cardiorespiratory function as measures of physical fitness using the complex, internationally recommended and widely used Euro fit physical fitness test battery and physical activity in children and adolescents with type 2 diabetes against an age-matched control group.

II. Methodology

204 children and adolescence (diabetic and non-diabetic) were identified at 80 schools (26 primary, 24 intermediate, and 30 secondary) in Egypt during the study period from October 2011 to September 2014. In Cairo governorate, Children start primary, intermediate and secondary education at age 6, 10, and 14 years, respectively. Children and adolescences' age between 8 and 18 years , their height between 120 and 170 cm for girls and between 120 and 180 cm for boys and their BMI between 25-28 kg/m2. Children and adolescences who were able to perform the Euro fit tests , and were not acutely ill for one month were included in the study. The duration of diabetes of those Children and adolescences was at least 1 year. Participants who had evidence of diabetic complications by regular assessments for retinopathy (fundal photography), nephropathy (microalbuminuria), and neuropathy (nerve conduction velocity and cardiovascular reflex tests) were excluded from the study. To have comparable groups for analyzing the results, diabetic and control subjects were divided into four groups according to age and gender, respectively: younger girls and boys (8-12 yr), older girls and boys (13-18 yr). The primary data source was the medical records which are created and updated annually by the schools' physicians, who undertake medical checkups for all school children at the beginning of each year. Diagnosis of type 2 diabetes was made according to the World Health Organization [17] and the American Diabetes Association [10] criteria which stipulate that type 2 diabetes was confirmed by fasting blood glucose ≥126 mg/dl (7.0 mmol/l). Fasting is defined as no caloric intake for at least 8 h. The secondary data source was independent of the primary data source and was obtained by asking all children and parents about the presence of type 2 diabetes. All the diabetic children and adolescence were managed with medical nutrition and pharmaceutical therapy. In order to compare the frequency of a family history of diabetes in the affected children, a group of non diabetic classmates was selected. The study group consisted of 102 children and adolescence with T2D aged 8–18 years from, The control group consisted of the same number of non diabetic peers of equal age and sex, with a similar height (not greater than 2 cm), weight (not greater than 2 kg), length of the lower extremities, BMI. It is accepted that BMI is a reliable and valid index of relative adiposity in children and adolescents and is in widespread use but BMI may misclassify people who are very tall or small or have highly developed muscles [28]. Therefore, we chose to add skinfold thickness, a more specific measurement of adiposity, to our definition of obesity to avoid misclassification Stature was measured to the nearest 0.1 cm using a stadiometer (Holtain Ltd., Crymmych, Pembs, United Kingdom). Body mass was measured to the nearest 0.1 kg on a digital balance scale (maximum 200 kg; Seca, Hamburg, Germany) with the subject wearing sports clothing and no shoes. BMI was calculated from height and weight measures. An estimation of body fat by skinfold thickness measurements was made at four sites (biceps, triceps, subscapular and suprailiac) on the right side of the body by the same experienced examiner in the standard manner using a Harpenden skinfold calliper (HSB-BI, British Indicators Ltd., UK) according to the International Society for the Advancement of Ki anthropometry . Three non-consecutive measurements for all sites were performed and mean values were used analyzing the data. As there is no standard for evaluating body fat content in percentage for children and adolescents, the skinfold thickness was summed in millimeters [29]. Children and adolescence of both groups were defined as body mass index (BMI) (kilograms per meters squared) and sum of skinfolds (millimeters) above the 90th percentile for the respective subgroup.

The physical fitness of the subjects was investigated with the standardized Euro fit Physical Fitness Test Battery that was devised by the Committee of Experts for Sports Research of the Council of Europe [18]. This battery examines nine tests: eight motor performance tests and the cardiorespiratory fitness test. 1) Motor performance tests consist of the evaluation of the total body balance (Flamingo test, FLB), 2) Speed and coordination of upper limb movement (Plate tapping test, PLT), 3) General flexibility (Sit and reach test, SAR), 4) Explosive strength of legs (Standing broad jump test, SBJ), 5) Static strength of the hand and forearm (Hand grip test, HGR), 6) Abdominal muscle strength (Sit-up test, SUP), 7) Upper body strength (Bent arm hang test, BAH), and 8) Running speed – agility (10 x 5 meter shuttle run test, SHR). 9) The test for cardiorespiratory fitness utilizes the maximal oxygen uptake (VO2max) as the single best measure of maximal aerobic power [30]. The VO2max was predicted from the 20-m endurance shuttle run test using regression equation proposed by Léger at al [31, 32]. The validity of the test to predict the maximal oxygen consumption has been previously established [33, 34]. Motor performance and cardiorespiratory fitness tests were carried out at 08.00-10.00 hours. If the patient's morning home blood glucose result was out of the target range (5-10 mmol/L), a new appointment was given to perform the test on another day. Physical activity was estimated using a modified version of the Baecke Questionnaire [35]. Responses to 13 questions were scored on a five-point scale and resulted in two indices reflecting physical activity during sport (sport index) and during leisure time excluding sport (leisure-time index). Items regarding physical activity during work were omitted from this study, and there were some small modifications in the formulation of certain items. The validity of the Baecke Questionnaire for the assessment of physical activity has been reported previously [36–37].

Statistical analysis

Descriptive characteristics (mean and SD) were performed for all parameters. SPSS version 19.0 statistical analysis software was used for data analyses and p values ≤ 0.05 were considered statistically significant. The Shapiro-Wilk test was used to evaluate normality of the data set. To compare the results of the diabetic and the control groups, an independent t-test and a Mann- Whitney U test were used according to the normality of distribution.

Table 1. Euro fit tests of physical fitness [18, 38, and 39].

Dimension	Factor	Euro fit Test
Cardio respiratory endurance	Cardio-respiratory endurance	- Endurance shuttle run (ESR)
		Bicycle ergometer test (PWC 170)
Strength	Static strength	Hand grip (HGR)
	Explosive power	Standing broad jump (SBJ)
Muscular endurance	Functional strength	Bent arm hang (BAH)
	Trunk strength	Sit-ups (SUP)
Speed	Running speed – agility	- Shuttle run: 10 x 5 meters (SHR)
	Speed of limb movement	Plate tapping (PLT)
Flexibility	Flexibility	Sit and reach (SAR)
Balance	Total body balance	Flamingo balance (FLB)
Anthropometric measures	Height (cm): Weight (kg): Body fat (5 skinfolds: biceps; triceps; subscapular, suprailiac, calf)	
Identification data	Age (years, months): Sex:	

III. Results

Table 2,3 present the demographic and anthropometric measures for the children and adolescents in the study and control groups. At a predetermined arrangement with the principal and class, children were provided with informational flyers that were submitted to parents for review and eventual approval. Signed approval was given by parents and the participant. In the current study, results in table (3) showed that younger obese girls with diabetes had significantly poorer results on the PLT test, SUP test, BAH test, SHR test, VO2max than age-matched girls in the control group. Older girls with diabetes in had significantly poorer results on the PLT test, SUP test, BAH test and VO2max than age-matched controls. Table (4) showed that there were poorer results in the groups of younger and older boys with diabetes as compared with the non-diabetic control group, respectively. Younger boys with diabetes had a significantly reduction in the PLT test, SAR test; HGR test and SUP test than age-matched control boys. Older boys with diabetes had significantly poorer results on the PLT test, SAR test, SUP test, BAH test and VO2max than age-matched control boys.

Table 2. Characteristics of girls' participants. (Aged 8-12yr)

Characteristic	Girls 8-12yr		Girls 13-18 yr	
	Study group	Control group	Study group	Control group
	X± SD	X± SD	X± SD	X± SD
n	26	25	24	27
Age [yr]	10.3±1.45	10.4±1.04	15.8±1.75	16.4±1.04
BMI , kg/m	26.3±3.2	25.9±3.09	25.2±3.5	25.9±3.09
Sum of skinfolds (mm)	106.56 ±23.58	107.44 ±27.45	101.02 ±27.91	100.48 ±27.10
Diabetes Duration(yr)	4.39±2.53	--	5.89±2.63	--
HbA1c (%)	8.49±1.93	--	8.79±1.93	--
HbA1c(mmol/mol)	69±11.3	--	74.3±10.1	--

BMI, body mass index; HbA1c, hemoglobin A1c

Table 3. Characteristics of Boys participants.

BMI, body mass index; HbA1c, hemoglobin A1c

Group	Boys 8-12yr		Boys 13-18 yr	
Characteristic	Study group	Control group	Study group	Control group
	X± SD	X± SD	X± SD	X± SD
n	26	24	25	27
Age [yr]	10.53± 1.5	11.02 ±1.13	15.43± 1.8	16.02 ±1.63
BMI kg/m^2	27.56 ±3.12	26.21±3.74	26.76 ±3.42	27.31±3.94
Sum of skinfolds(mm)	117.62 ±24.93	113.44 ±31.47	105.97 ±26.58	109.49 ±22.41
Diabetes Duration	3.76 ±2.74	--	6.24 ±3.94	--
HbA1c (%)	8.22±1.53	--	8.52±1.53	--
HbA1c(mmol/mol)	66± 12.8	--	70± 12.6	--

Table 3. Eurofit test of girls with type 2 diabetes compared to non diabetic control groups:

Group	**Girls 8-12yr**		**P-value**	**Girls 13-18 yr**		**P-value**
Characterstic	**Study group**	**Control group**		**Study group**	**Control group**	
	X± SD	**X± SD**		**X± SD**	**X± SD**	
Physical fitness						
LB* (No of error)	**8.33 ±4.35**	**6.63 ±6.01**	**0.095**	**9.65 ±6.52**	**9.03 ±6.28**	**0.716**
PLT† (sec)	**14.80 ±3.23**	**12.29 ±3.48**	**0.022***	**12.32 ±1.80**	**11.13 ±1.82**	**0.013***
SAR (cm)	**19.17 ±5.48**	**19.66 ±4.42**	**0.951**	**22.52 ±6.40**	**20.65 ±6.21**	**0.250**
SBJ (cm)	**153.41 ±21.02**	**167.56 ±18.17**	**0.419**	**150.31 ±24.86**	**147.22 ±23.90**	**0.259**
HGR (kg)	**19.44 ±4.73**	**19.72 ±4.80**	**0.826**	**35.31 ±4.73**	**31.57 ±4.17**	**0.514**
SUP(attempt)	**18.11 ±5.78**	**22.63 ±5.43**	**0.001***	**19.77 ±5.57**	**23.41 ±4.19**	**0.036***
BAH (sec)	**2.61 ±2.83**	**9.98 ±7.39**	**0.025***	**2.77 ±2.55**	**10.58 ±5.41**	**0.008***
SHR (sec)	**24.30 ±2.06**	**23.16 ±2.09**	**0.040***	**23.42±2.13**	**23.28±2.25**	**0.806***
VO2max (ml/min/kg)	**43.14 ±4.33**	**46.42 ±4.17**	**0.006***	**33.2 1 ±4.8**	**36.48 ±5.96**	**0.015***
Physical activity						
LTI	**2.8 ± 0.6**	**2.9 ± 0.6**	**0.213**	**2.8 ± 0.7**	**3.0 ± 0.7**	**0.359**
SI	**2.4 ± 0.7**	**2.8 ± 0.7**	**0.417**	**2.5 ± 0.9**	**2.5 ± 0.7**	**0.431**

BAH, bent arm hang; FLB, Flamingo balance; HGR, hand grip; PLT, plate tapping; SAR, sit and reach; SBJ, standing broad jump; SHR, 10 x 5 m shuttle run; SUP, sit-ups. -numbers of steps down from the beam losing the balance -time for touching two discs 25 times back and forth; LTI, Leisure-time index; SI, Sport index, *p<0.05.

Table 4. Euro fit test of boys with type 2 diabetes compared to non diabetic control groups:

Group	Boys 8-12yr		P-value	Boys 13-18 yr		P-value
Characteristic	Study group	Control group		Study group	Control group	
	X± SD	X± SD		X± SD	X± SD	
Physical fitness						
LB* (No of error)	9.68 ±5.23	7.18 ±6.01	0.054*	9.39 ±6.57	6.58 ±5.75	0.066
PLT† (sec)	15.19 ±3.40	13.54 ±2.00	0.025*	13.26 ±1.47	12.47 ±1.97	0.006*
SAR (cm)	14.58 ±5.44	18.23 ±4.41	0.009*	16.50 ±7.77	20.63 ±7.46	0.038*
SBJ (cm)	166.64 ±24.57	171.25 28.65	0.535	193.70 ±24.46	201.35 ±31.15	0.440
HGR (kg)	41.05± 6.06	39.25± 22.89	0.050*	35.44±8.25	40.14± 5.02	0.248
SUP(attempt)	20.60 ± 6.01	24.89±3.45	0.036*	20.39±4.18	23.12± 7.03	0.013*
BAH (sec)	6.01± 5.61	16.00±5.96	0.979	11.36±3.66	20.10 ±10.12	0.030*
SHR (sec)	22.39 ±2.48	21.80 ±3.32	0.103	22.45 ±1.70	20.96±2.51	0.386
VO2max (ml/min/kg)	45.58 ±3.30	46.89 ±5.60	0.298	38.72 ±5.20	44.80±7.29	0.000*
Physical activity						
LTI	2.8 ± 0.6	2.9 ± 0.6	0.431	2.8 ±0.7	3.0 ± 0.7	0.219
SI	2.5 ± 0.6	2.6 ± 0.6	0.361	2.5 ± 0.9	2.5 ± 0.7	0.199

BAH, bent arm hang; FLB, Flamingo balance; HGR, hand grip; PLT, plate tapping; SAR, sit and reach; SBJ, standing broad jump; SHR, 10 x 5 m shuttle run; SUP, sit-ups. *-numbers of steps down from the beam losing the balance †-time for touching two discs 25 times back and forth; LTI, Leisure-time index; SI, Sport index, *p<0.05 .

IV. Discussion

Type 2 diabetes in children and adolescences, as in adults, is due to the combination of insulin resistance and a relative *β*-cell secretory failure. There appear to be a host of genetic and environmental risk factors for insulin resistance and limited *β*-cell reserve. Family history of type 2 diabetes, ethnicity, pubertal augmentation of growth hormone/IGF secretory dynamics, and intrauterine exposure to maternal diabetes, low birth weight, sedentary lifestyle and female gender in association with hyperandrogenism are associated with this condition [9]. Primary prevention of type 2 diabetes in children and adolescents should ideally include a public health approach that targets the general population. Health professionals need to be involved in developing and implementing school- and community-based programs to promote improved dietary and physical activity behaviors for all children and their families [38-39].

In this study, motor performance and cardiorespiratory fitness of children and adolescents with type 2 diabetes were investigated using the standardized Euro fit test battery and the Baecke Questionnaire. The results were compared with findings from age-matched control groups. Children and adolescents with diabetes of both sexes exhibited substantially poorer physical fitness levels in several tests than their non-diabetic peers. To our knowledge, this is the first trial, in which parallel assessments of motor performance, and cardiorespiratory function were carried out in children and adolescences with type 2 diabetes using Eurofit test battery. These tests are standardized and widely used methods of estimation the complex physical fitness of children and adolescents [40-41].

The reason why children and adolescences with type 2 diabetes showed impaired performances on various tests for physical fitness is not clear. It has been suggested that lower physical activity or physiological changes resulting from the pathology of diabetes itself could result in reduced fitness in children [42, 43]. Another possibility is that early subclinical complications of diabetes or diabetic myopathy may contribute to reduced physical fitness achievements. Early complications can be present in children with diabetes, and in a previous trial, cardiovascular autonomic dysfunction was found to interfered with exercise testing results [44]. More importantly, previous studies showed that poor metabolic control was associated with poor cardiorespiratory fitness in children with diabetes [42-44].

In a previous study, children with diabetes were found to have lower achievement in body balance, long jump and handgrip tests; however this study did not investigate cardiorespiratory fitness [45]. In this study, the female gender, increasing age, higher skinfold thickness, lower physical activity level, and poor long-term metabolic control were significant independent predictors of lower VO2max as a measure of cardiorespiratory fitness[46-47]. Poor performances may have also been due to the fact that the excess body fat of children (measured by skin fold thickness) in both groups represents an extra load to be moved during weight-bearing tasks [48].

Another explanation could be that obese children and adolescents avoid weight-bearing activities because of the greater energy cost compared with normal-weight children [49]. In this case, the poorer performance could also be a consequence of a lack of experience in weight-bearing tasks. Because young boys and girls are limited in their ability to perform weight-bearing activities, such activities should be restricted at the start of an intervention [49-52]. Other studies have also found negative relationships between fatness and performance on weight-bearing tasks in 12- to 27-year-old subjects [53–54]. Also in tests requiring flexibility, coordination, or speed of limb movement (plate tapping and sit-and-reach), excess fat is not likely to hinder performance [53, 56]. Minck et al. [54] found no relationship between these fitness components and degree of fat in 6- to 27-year-old subjects, whereas Pate et al. [51] found inconsistent results concerning the relationship between scores on the sit-and-reach test and fatness in boys and girls 6 to 18 years of age.

According to the present results, all diabetic groups had impaired speed and coordination of upper limb movement and abdominal muscle strength. In addition, all girls with diabetes had less upper body strength and maximal oxygen uptake. Furthermore, younger girls with diabetes had poorer running speed as well. Moreover, all boys with diabetes had poor general flexibility and younger boys with diabetes had poor static strength of the hand and forearm and older boys with diabetes showed less upper body strength and maximal oxygen uptake. In a previous study, children with diabetes had lower achievement in body balance, long jump and handgrip tests; however this study did not investigate cardiorespiratory fitness [55]. In another study, pre-pubertal boys with diabetes had normal cardiorespiratory fitness [56] similarly to the present study where younger boys with diabetes also had no impairment of this parameter.

Children and adolescents with T2DM may have some impaired fitness-related components and alterations in their cardiorespiratory responses to exercise especially if they are in fair to poor metabolic control. It is currently unclear, however, whether the observed lower aerobic performance is a function of a reduced level of habitual activity, a smaller body stature, or impairment in cardio-respiratory or skeletal muscle function. In some children, inactivity probably contributes to the decreased performance [57].

The second research question was related to differences in physical activity level between the diabetic and non diabetic groups. Results showed that no differences in leisure-time physical activity (excluding sport) between both groups for both sexes. In girls, the sport index was comparable between the diabetic and non diabetic, whereas in boys, the diabetic children and adolescences had a lower sport index than their non diabetic peers. These findings are in agreement with other studies in the literature. Huttunen et al. [57] found no differences in habitual physical activity levels between obese and non obese 11-year-old children, but obese children participated less frequently in a sports club than the normal-weight children. In the study by Garaulet et al. [58], which investigated 14- to 18-year-old adolescents, overweight girls showed nearly identical levels of physical activity (work, sport, and recreational index) compared with their non overweight counterparts, but overweight boys had a significantly lower sport index than their non overweight peers. The lack of differences in the sport index between diabetic and non diabetic girls could be due to the fact that sports clubs for girls are less competitive. A possible explanation for this sex difference could be that moderate-to high intensity physical activity or sport participation plays a less important role in the development of overweight in girls.

This finding emphasizes the importance of physical fitness in the care of diabetes and suggests that improvement in physical condition may contribute to better diabetic control which in turn leads to further improvement in physical performance. Although, children and adolescents need all types of movements for improving different physical abilities and strengthen muscle groups, but the glycemic control seems to be influenced primarily by the physical activity. This indicates the importance of the activity in the treatment and care of type 2 diabetes in childhood. Further studies are necessary to investigate whether very early micro vascular, neuropathic, or muscle alterations may contribute to the impairment of motor or cardiorespiratory performances.

V. Conclusion

In conclusion, both motor performance and cardiorespiratory fitness can be impaired in children and adolescence with type 2 diabetes, this underlying the importance of life style interventions in the complex treatment and care of childhood diabetes. Regular and parallel assessments of motor and cardiorespiratory functions by the Euro fit battery tests may help to identify the individual needs of special exercise activities. This may also contributes to better physical condition and metabolic control of children and adolescents with type 2 diabetes. However, further studies are necessary to explain the mechanisms by which diabetes leads to reduced fitness and to examine the effect of lifestyle intervention on the feasibility of improving cardiovascular fitness. Programs that provide children and their families with the knowledge, attitudes, behavioral skills, and encouragement to consume a healthy diet and engage in regular physical activity may be effective in attenuating the expanding problem of obesity. At the community level, schools, religious organizations, youth and family organizations, and government agencies should assume some responsibility for promoting a healthy lifestyle.

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References

[1]. Sperling M. Diabetes mellitus. In: Waldo N, eds. Nelson textbook of paediatrics. W.B.Saunders Company, 1996:1647.
[2]. World Health Organization. Definition, diagnosis and classification of diabetes mellitus and its complications. Geneva: World Health Organization, 1999.
[3]. Temple I., Shield J. Transient neonatal diabetes, a disorder of imprinting. J Med Genet 2002; 39:872–5.
[4]. Basma A. Ali, Samir T. Abdallah, Ahlam M. Abdallah, Mahmoud M. Hussein. The Frequency of Type 2 Diabetes Mellitus among Diabetic Children in El Minia Governorate, Egypt. Sultan Qaboos University Med J, 2013; 13(3): 399-403.
[5]. Hannon T., Rao G., Arslanian S. Childhood obesity and type 2 diabetes mellitus. Pediatrics. 2005 Aug; 116(2):473-80.
[6]. Kaufman F. Type 2 diabetes in children and youth: A new epidemic. J Pediatr Endocrinol Metab 2002; 15:737–744.
[7]. Caprio S., Tamborlane W. Metabolic impact of obesity in childhood. Endocrinol Metab Clin North Am 1999; 28:731–747.
[8]. Caprio S. Insulin resistance in childhood obesity. J Pediatr Endocrinol Metab 2002; 15:487–492.
[9]. Francine R. Type 2 Diabetes in Children and Youth Reviews in Endocrine & Metabolic Disorders 2003; 4:33–42.
[10]. American Diabetes Association: Type 2 diabetes in children and adolescents (Consensus Statement). Diabetes Care 23: 381–389, 2000.
[11]. Pinhas-Hamiel O., Dolan L., Daniels S., Standiford D., Khoury P., Zeitler P. Increased incidence of non-insulin-dependent diabetes mellitus among adolescents. J Pediatr 1996; 128:608–615.
[12]. Glaser N., Jones K. Non-insulin-dependent diabetes in childhood and adolescents. Adv Pediatr 1996; 43:359–396.
[13]. Ehtisham S., Barrett T., Shaw N. Type 2 diabetes mellitus in UK children—an emerging problem. Diabet Med 2000; 17:867–71.
[14]. Kitagawa T., Owada M., Urakami T. Tajima N. Epidemiology of type 1 (insulin-dependent) and type 2 (non-insulin-dependent) diabetes mellitus in Japanese children. Diabetes Res Clin Pract 1994; 24:7–13.
[15]. Fagot-Campagna A. Emergence of type 2 diabetes mellitus in children – Epidemiological evidence. J Pediatr Endocrinal Metab 2000; 13:1395–402.
[16]. World Health Organization Expert Committee. Physical Status: The Use and Interpretation of Anthropometry. World Health Organization: Geneva; 1995.
[17]. Council of Europe (1987). Recommendation no. r (87) 9 of the Committee of ministers to member states on the EUROFIT tests of physical fitness. Retrived March 14, 2012 from the World Wide Web: http://www.coe.int/t/dg4/epas/resources/sportpolicies_en.asp
[18]. Warburton D., Gledhill N. and Quinney A. The effects of changes in musculoskeletal fitness on health. Can J Appl Physiol. 2001; 26(2):161-216.
[19]. Warburton D., Nicol C. and Bredin S. Health benefits of physical activity: the evidence. CMAJ.2006; 174(6):801-9.
[20]. Wiesław B., Katarzyna M. Karolina H. Physical activity of children and adolescents with intellectual disabilities – a public health problem. Hygeia Public Health 2013;48(1): 1-5
[21]. Diabetes Prevention Programme Research Group. Reduction in the incidence of Type 2 diabetes with lifestyle intervention metformin. N Engl J Med 2002; 346: 393 – 403.
[22]. Tuomilehto J., Lindstrom J., Eriksson J., Valle T., Hamalainen H., Ilanne-Parikka P. et al. Prevention of Type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance. N Eng J Med 2001; 344: 1343 – 1350.
[23]. Boule N., Haddad E., Kenny G., Wells G and Sigal R. Effects of exercise on glycaemic control body mass in Type 2 diabetes: a meta-analysis of controlled clinical trials. J Am Med Assoc 2001; 286: 1218 – 1227.
[24]. Kirk A., Mutrie N., MacIntyre P. and Fisher M. Increasing physical activity in people with type 2 diabetes. Diabetes Care 2003; 26: 1186 – 1192.
[25]. Lehmann R., Kaplan V., Bingisser R., Bloch K., Spinas G. Impact of physical activity on cardiovascular risk factors in IDDM. Diabetes Care 1997; 20: 1603 – 1611.
[26]. Laaksonen D., Atalay M., Niskanen L., Mustonen J., Sen C., Lakka T. et al. Aerobic exercise and the lipid profile in type 1 diabetic men. A randomized controlled trial. Med Sci Sports Exerc 1999; 32: 1541 – 1548.
[27]. Defronzo A., Elliott P. and Shipley M. Body mass index versus height and weight in relation to blood pressure. Findings for the 10,079 persons. Am J Epidemiol 2001; 131:589-596.
[28]. Marfell-Jones M., Olds T., Stewart A. and Carter L. International standards for anthropometric assessment. 2nd edn. 2006; Potchefstroom, South Africa, 57-66.
[29]. Hyde T. and Gengenbach M. Conservative Management of Sports Injuries, 2 2007; Sudbury: Jones & Bartlett, 845.
[30]. Léger L. and Lambert J. A maximal multistage 20-m shuttle run test to predict VO2 max. Eur J Appl Physiol Occup Physiol 1982; 49: 1-12.
[31]. Léger L., Mercier D., Gadoury C. and Lambert J. The multistage 20 metre shuttle run test for aerobic fitness. J Sports Sci 1988; 6: 93-101.
[32]. Ramsbottom R., Brewer J. and Williams C. A progressive shuttle run test to estimate maximal oxygen uptake. Br J Sports Med 1988; 22: 141-144.
[33]. Liu N., Plowman S. and Looney M. The reliability and validity of the 20-meter shuttle test in American students 12 to 15 years old. Res Q Exerc Sport 1992; 63: 360–365.
[34]. Baecke J., Burema J. and Frijters J. A short questionnaire for the measurement of habitual physical activity in epidemiological studies. Am J Clin Nutr. 1982; 36:936 – 42.
[35]. Pols M., Buenodemesquita H., Ocke M., Wentick C., Kemper H. and Collette H. Validity and repeatability of a modified Baecke questionnaire on physical activity. Int J Epidemiol. 1995; 24:381– 8.
[36]. Phillippaerts R., Westerterp K. and Lefevre J. Doubly labeled water validation of three physical activity questionnaires. Int J Sports Med. 1999; 20:284 –9.

[37]. España-Romero, V., Artero, E., Jimenez-Pavón, D., Cuenca-Garcia M., Ortega, F., Castro-Piñero, J., et al. Assessing health-related fitness tests in the school setting: reliability, feasibility and safety; The ALPHA Study. International Journal of Sports Medicine 2010; 31 (7), 490-497.
[38]. Maggio A., Hofer M., Martin X., Marchand L., Beghetti M. and Farpour-Lambert N. Reduced physical activity level and cardiorespiratory fitness in children with chronic diseases. Eur J Pediatr 2010; 169: 1187-1193.
[39]. Williams B., Guelfi K. and Jones T., Davis E. Lower cardiorespiratory fitness in children with type 1 diabetes. Diab Med 2011; 28: 1005-1007.
[40]. Adam C., Klissouras V., Ravazzolo M., Renson R. and Tuxworth W. Euro fit: European Test of Physical Fitness. Rome, Italy: Council of Europe,Committee for the Development of Sport; 1988. American Diabetes Association. Type 2 Diabetes in Children and Adolescents Pediatrics; 105 (3): 2000.
[41]. Huttunen N., Käär M., Knip M., Mustonen A., Puukka R. and Akerblom H. Physical fitness of children and adolescents with insulin-dependent diabetes mellitus. Ann Clin Res 1984; 16: 1-5.
[42]. Barkai L, Peja M, Vámosi I. Physical work capacity in diabetic children and adolescents with and without cardiovascular autonomic dysfunction. Diabetic Med 1996; 13: 254-258.
[43]. Wiśniewski A., Poliszczuk T. and Pańkowska E. Assessment of physical fitness in children and teenagers with type 1 diabetes. Pediatr Endocrinol Diabetes Metab 2010; 16: 171-175.
[44]. Michaliszyn S., Quinn L., Fritschi C., Faulkner M. Physical fitness, dietary intake and metabolic control in adolescents with type 1 diabetes. Pediatr Diabetes 2009; 10: 389-394.
[45]. Lukács A., Mayer K., Juhász E., Varga B., Fodor B., Barkai L. Reduced physical fitness in children and adolescents with type 1 diabetes. Pediatr Diabetes 13: 432-437.
[46]. Hills A. and Byrne N. Exercise prescription for weight management. Proc Nutr Soc. 1998; 57:93–103.
[47]. Bar-Or O. Physical activity and physical training in childhood obesity. J Sports Med Phys Fitness. 1993; 33:323–9.
[48]. Sothern M. Exercise as a modality in the treatment of childhood obesity. Pediatr Clin North Am; 2001; 48:4:995–1015.
[49]. Sothern MS, Hunter S, Suskind RM, Brown R, Udall JN, Blecker U. Motivating the obese child to move: the role of structured exercise in pediatric weight management. South Med J. 1999; 92:577–83.
[50]. Bar-Or O. Obesity. In: Goldberg B, ed. Sports and Exercise for Children with Chronic Health Conditions. Champaign, IL: Human Kinetics; 1995, pp. 335–53.
[51]. Pate R., Slentz C. and Katz D. Relationships between skinfold thickness and performance of health related fitness test items. Res Q Exerc Sport. 1989; 60:183–9.
[52]. Malina R. et al. Fatness and physical fitness of girls 7 to 17 years. Obes Res. 1995; 3:221–31.
[53]. Beunen G., Malina R., Ostyn M., Renson R., Simons J. and Van Gerven D. Fatness, growth and motor fitness of Belgian boys 12 through 20 years of age. Hum Biol. 1983; 55:599– 613.
[54]. Minck M., Ruiter L., Van Mechelen W., Kemper H. and Twisk J. Physical fitness, body fatness, and physical activity: the Amsterdam Growth Study. Am J Hum Biol. 2000; 12:593–9.
[55]. Heyman E., Briard D., Gratas-Delamarche A., Delamarche P. and De Kerdanet M. Normal physical working capacity in prepubertal children with type 1 diabetes compared with healthy controls. Acta Paediatr 2005; 94: 1389-1394.
[56]. Riddell M. and Iscoe K. Physical activity, sport, and pediatric diabetes. Pediatric Diabetes 2006: 7: 60–70.
[57]. Huttunen N., Knip M. and Paavilainen T. Physical activity and fitness in obese children. Int J Obes Relat Metab Disord. 1986; 10:519–25.
[58]. Garaulet M., Martinez A., Victoria F., Rerez-Llamas F., Ortega R. and Zamora S. Differences in dietary intake and activity level between normal-weight and overweight or obese adolescents. J Pediatr Gastroenterol Nutr. 2000; 30:253–8.