Running title: Physical activity in young diabetic subjects

Corresponding author:

Nina Cecilie Øverby

University of Oslo

Faculty of Medicine

Institute of Basic Medical Sciences

Department of Nutrition

Pb 1046 Blindern

0316 OSLO

Norway

Telephone: +0047 22851354

Fax: +0047 22851531

E-mail: ninaco@medisin.uio.no

Physical activity and overweight in children and adolescents using intensified insulin treatment

Nina C Øverby; MSc [1], Hanna D Margeirsdottir; MD[2], Cathrine Brunborg; MSc [3], Sigmund A Anderssen; PhD[4], Lene F Andersen; PhD [1], Knut Dahl-Jørgensen; MD PhD [2,5] and Norwegian Study Group for Childhood Diabetes.

[1] Department of Nutrition, Institute of Basic Medical Sciences, Faculty of Medicine, University of Oslo, Norway

[2] Department of Pediatrics, Ullevaal University Hospital, Oslo, Norway

[3] Center for Clinical Research, Ullevaal University Hospital, Norway

[4] Department of Sports Medicine, Norwegian School of Sport Sciences, Oslo, Norway

[5] Faculty of Medicine, University of Oslo, Oslo, Norway

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Abstract:

Aim: To describe physical activity and inactivity and parameters associated with overweight in a population based study of children and adolescents on intensive insulin treatment.

Methods: Physical activity and inactivity was evaluated in 723 type 1 diabetic subjects, 240 children aged 6-10 years and 483 adolescents aged 11-19 years, using a questionnaire that can estimate total amount of time spent on inactivity and light, moderate and vigorous activity.

Results: Overall 54% of the participants do not fulfil the international recommendations of 60 minutes of moderate to vigorous activity per day. Girls are less active than boys in both childhood (70 vs 88 min/day, $p=0.01$) and adolescence (47 vs 57 min/day, $p=0.02$). Furthermore this study shows that those who are more active are also those who seldom skip meals ($p<0.001$). Forty three percent of the participants watch TV for more than 2 hours a day and TV viewing was found to be associated with overweight in children and adolescents with type 1 diabetes (OR: 2.5 (1.40-4.54), $p=0.002$).

Conclusion: To increase physical activity to recommended level and limit TV viewing should be an important issue in education of children and adolescents with type 1 diabetes.

Key words: adolescents, children, physical activity, type 1 diabetes, overweight

Introduction:

Physical activity has long been recommended to children and adolescents with type 1 diabetes as an important component of the diabetes management. There are evidence based physical activity recommendations for school age youth which suggests that they should participate daily in 60 minutes or more of moderate to vigorous physical activity (1). Some of the beneficial effects of regular physical activity in type 1 diabetic subjects are less excessive weight gain, increased insulin sensitivity, increased sense of wellbeing, social interaction and reduced risk of later cardiovascular disease (1-3). There have been conflicting results on the long term effect of physical activity on blood glucose control (4-7). Diabetic subjects are more prone to overweight than their healthy peers and have an increased risk of cardiovascular disease compared to the general population (8;9). Furthermore, imaging techniques have shown that atherosclerosis develops earlier and is more prevalent in childhood onset diabetes than in age-matched controls (8;10;11). Only few studies have examined physical activity and inactivity in children and adolescents with type 1 diabetes (2;4;7;12;13), and none systematically so in patients using intensified treatment. In the present population based study we describe the physical activity and inactivity and parameters associated with overweight in type 1 diabetic children and adolescents.

Subjects:

The subjects were recruited in 2004 and 2005 among participants in the "The Norwegian Childhood Diabetes and Quality project" (NCDQ), a prospective population based study with a participation rate of 85% (hospital range 44-99%) including children and adolescents aged 0-19 years. The classification of type 1 diabetes mellitus is ensured by measurements of auto antibodies (Insulin, GAD, IA2) and C-peptide at diagnosis. Children with type 2 diabetes mellitus were not included.

Total number of participants in NCDQ was 1935. A total of 768 children and adolescents answered questions about their physical activity. This gives a participation rate of 40%. Forty-five subjects were excluded because they were less than 6 years old, and in the present analyses 723 persons are included, 543 from 2004 and 180 from 2005. All 723 persons had information on meal frequency and snacking events. The mean age was 12 years with range from 6-19 years and the mean diabetes duration was 4.6 years. Due to a low participation rate, HbA1c and BMI was compared between the responders and the non-responders with data from NCDQ (n=928). HbA1c was significantly lower in the responders (mean difference: 0.3%, $p<0.001$) compared to non-responders, while there were no significant differences in BMI (mean difference 0.2 kg/m^2, $p=0.30$) when adjusted for age and gender.

The data collection was carried out from January to April. An invitation letter and the physical activity questionnaire were sent to all participants in the NCDQ project. Those who agreed to participate returned a written consent and the completed questionnaire. The study protocols were approved by the National Committee for Research Ethics in Norway and the Norwegian Social Science Data Services.

Methods

The questionnaire includes questions on physical activity and inactivity, body weight and height and meal frequency. The physical activity questionnaire has 19 questions on activity including intensity on week days and week ends and during school and after school. The questionnaire can estimate total amount of time spent on inactivity and light, moderate and vigorous activity. The questionnaire has been validated against a physical activity monitor ActiReg® (14). When dividing the activity in different intensity groups the correlation between the two methods of time used on each activity level was r=0.6 for light activity and r=0.48 both for moderate and for vigorous activity (15). Clinical information was obtained from case record forms from the NCDQ project.

Calculation of physical activity

Mean frequency of the activity per week, single-session duration and intensity (graded 1-4) were assessed for the participants' usual activities. For each intensity grade, activity-specific metabolic equivalent (met) values were used according to Ainsworth et al (16). Total amount of physical activity was calculated by multiplying time spent on the activities by the intensity expressed in met. Time spent on moderate activity (3-6 mets) and vigorous activity (>6 mets) are presented. To be able to calculate the activity all participants had to have 24 hours of reported time in the questionnaire. The mean reported time in the questionnaires was 20.9 hours on week days and 16.8 hours on weekends. On average a supplement of 3.1 hours on week days and 7.2 hours on week end days with energy intensity of 1.5 mets were added. School hours were set to 4.5 hours for all participants each week day, and school breaks were calculated to 45 minutes per day.

Laboratory methods

HbA1c has been determined by a DCCT-standardized high performance liquid chromatography method (Variant; Bio-Rad, Richmond, CA). All samples were sent to the same central laboratory (Central laboratory, Aker University hospital). Normal reference was 4.1-6.4% (2SD), intra-assay coefficient of variation was <3%. Lipid profiles were measured by conventional methods in the non-fasting state. Blood pressure was measured according to the National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents (17).

Definitions

The 2005 Physical Activity Recommendation by the US Center for Disease Control and prevention (CDC) (1) recommends youths to participate daily in 60 minutes of moderate to vigorous physical activity that is developmentally appropriate, enjoyable and involves a variety of activities (CDC recommendation). This recommendation is identical with the national recommendation in Norway (18). Weight and height were self reported and were used to calculate BMI (kg/m^2). International cut-off points for BMI for overweight were used (19). Inactivity includes time spent on reading, watching TV and using the computer. Skipping meals refers to skipping at least 7 main meals a week. The American Academy of Pediatrics has recommendations for children and adolescents to decrease inactivity and specifically reduce TV viewing to a maximum of 2 hours per day (20). Furthermore, intensive insulin treatment is defined as using insulin pump or using 3 or more injections a day.

Statistics

Time spent on different levels of activity and inactivity is presented as means with standard deviations (table 1). Demographic and clinical data are presented as means with standard deviations (SD) or proportions according to tertiles of time spent on moderate and vigorous activity (table 2) in two different age groups. Differences between tertiles were tested with one way ANOVA or chi-square test. Due to many comparisons in table 2 the Bonferroni-correction was used to adjust the significance level from 0.05 to 0.002. For the comparisons between the number who did not fulfil the recommendations on week days and weekend days a 2x2 table was used with Pearson chi-square test. Linear regression analysis was used to asses the relation between physical activity and HbA1c. Further multiple regression analysis was used to determine whether the association between physical activity and HbA1c remained significant after adjusting for other independent variables. Logistic regression analysis was performed to find parameters associated with overweight. Univariable tests where p-value less than 0.25 were considered candidate for multivariable model. The best fitted model was found by using forward regression including p-values of less than 0.1 and backward regression including p-values of less than 0.05. In addition age, gender and physical activity is included in the model. The associations are presented as odds ratios (OR) with 95% confidence intervals (table 3). All p-values are two-sided and a 5% level of significance was used in table 1 and 3. All statistical analyses were performed with SPSS 14.0 (SPSS Inc., Chicago, IL, USA).

Results

In a group of intensive insulin treated children and adolescents 54% do not fulfil the CDC recommendation of physical activity; more adolescents (58%) than children (47%) (p=0.01). Table 1 shows that boys on average are more active and in addition spend more time on inactivity (especially using computers) than girls. Figure 1 shows that there are a significantly higher percentage of participants who do not fulfil the recommendations on weekend days compared to week days in both age groups and genders. In total 48% do not fulfil the recommendation on week days compared to 71% on weekend days. Characteristics of the participants are presented according to tertiles of minutes spent on physical activity (moderate and vigorous) separated in two age groups (table 2). Among those who are less active there are more who skip meals than among those who are active (table 2). There was a significant association between total time spent on moderate activity (min/day) and HbA1c in the unadjusted analysis (Crude estimate:-3.5, 95%CI: (-7.0,-0.01), p=0.05), however not significant when adjusting for age, gender and diabetes duration (p=0.74). In total 43% of the participants watch TV for more than 2 hours a day. Those who watch TV on average more than 1 hour per day have higher odds of being overweight than those who watch TV less than 1 hour a day when adjusted for age, gender, physical activity, having breakfast and supper (table 3). Time spent on physical activity was not significantly associated with overweight.

Discussion

Compared to Norwegian non-diabetic 9- and 15-year olds where physical activity was evaluated objectively by an activity monitor, there were more diabetic subjects who did not fulfil the CDC recommendation; 47% in diabetic vs.17% non-diabetic 9-year-olds and 58% in diabetic vs 45% in non-diabetic in 15-year-olds (21). The comparisons should be done with caution due to different methods. The difference was particularly large among the children. This could be explained by short diabetes duration and parents mainly focusing the treatment on meals and insulin adjustments. Furthermore fear of hypoglycaemic events could lead to less physical activity. The pattern of girls being less active than boys and adolescents being less active than children is also seen in non-diabetic subjects (21). The participants are on average more active than what has previously been reported in young diabetic subjects from other countries (2;3). To our knowledge the difference in physical activity between week and weekend has not previously been described in diabetic children and adolescents, however has been reported in Norwegian non-diabetic subjects (21). Given these results promoting physical activity also during weekend should be an important issue in the guidance of type 1 diabetic youth.

We found no significant relation between HbA1c and time spent on physical activity when adjusting for age, gender and diabetes duration. The literature on the association between physical activity and HbA1c is conflicting (4-7). A recent German and Austrian study found a significant reduction in HbA1c with increasing time spent on physical activity in young diabetic patients (4). This study had far more participants than our study, but it did not consider the type or the intensity of the activity. A Swedish study using objectively measurements of physical activity found no relation with HbA1c and physical activity in

diabetic girls (7), while The FinnDiane study found a relation in women but not in men (22). Our results and the conflicting results in other studies could indicate that it is no clear effect of physical activity on HbA1c. A plausible explanation for this could be that many type 1 diabetic patients find it challenging to adjust insulin to physical activity and then the activity does not have an improved effect on HbA1c.

The American Academy of Pediatrics have recommendations for children and adolescents to decrease inactivity and specifically reduce TV viewing to a maximum of 2 hours per day (20). In the present study a large number of participants exceeded this recommendation. NCDQ has previously reported a continuous increase of HbA1c by every hour watching TV (12). In healthy children excessive TV viewing has also been linked to obesity (23-26) and in addition TV-viewing in childhood has been linked to adult health status (27). In concordance with this we found that time spend on TV viewing was associated with overweight when adjusted for relevant variables. However we found no relation with overweight and time spend on physical activity. A European study found that physical activity and TV viewing are separate entities and are differently associated with obesity in healthy young subjects (28). There is not necessarily a clear cause and effect relationship between TV viewing and obesity. It could be that watching TV yields a more sedentary lifestyle and high consumption of energy dense food and thereby causes overweight, or it could be that those who are overweight just watch more TV than normal weighted.

This study shows that children and adolescents with type 1 diabetes have potential to improve several habits that are known to increase risk of cardiovascular disease (8): First a large number of the patients do not fulfil the CDC recommendation of physical activity. Secondly we found that 43% of the participants on average watched TV for more than the maximum

recommended 2 hours a day. Thirdly this study showed an association with TV viewing and overweight. Additionally, there was a significant trend in adolescents towards skipping fewer meals with increasing activity, which we have previously reported to be beneficial with regard to HbA1c (29).

A limitation with our population based study is the low participation rate. Those who participated had a slightly lower HbA1c than those who did not participate, which may suggest that our group is a selection of those with best blood glucose control and thereby generalization should be done with caution. A further limitation is the self-reported height and weight which could introduce some errors. However a validation study was performed in 2000 to evaluate the validity of the self-reported height and weight data. A total of 88 fourth graders and 71 eight graders were given the same questionnaire used in the present study and filled in their weight and height. A few days later the weight and height were measured by project staff. The results demonstrated a high correlation between self-reported and measured height and weight in both age groups. Moreover there was a high sensitivity and specificity according to identified overweight (30).

Conclusion: Our results show that a large part of the young diabetic subjects in this study are less active and watch more TV than recommended and are also less active than healthy peers. Furthermore we found a significant relationship between overweight and TV viewing. To increase physical activity and limit TV viewing should be an important issue in education of children and adolescents with type 1 diabetes. Detailed instructions must be given on insulin dosing and food intake to help keeping a normal blood sugar during and after exercise.

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Duality of Interest: The authors are not aware of any duality of interest.

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Table 1 Time spent in minutes/day at different levels of physical activity in diabetic children and adolescents (Mean (SD)

	6-10-year-olds			11-19-year-olds		
	Boys n=121	Girls n=119	p[1]	Boys n=254	Girls n=229	p[1]
Levels of physical activity						
Moderate (min/day)[2]	88 (53)	70 (51)	0.01	57 (49)	47 (42)	0.02
Vigorous (min/day)[3]	0.5 (4)	0.3 (4)	0.78	8 (24)	3 (14)	0.01
Inactivity (min/day)	200 (66)	167 (61)	<0.001	263 (97)	231 (85)	<0.001
- TV viewing (min/day)	105 (44)	102 (46)	0.53	126 (58)	136 (59)	0.05
-Using computer (min/day)	70 (39)	40 (27)	<0.001	105 (71)	59 (50)	<0.001
-Reading (min/day)	25 (16)	26 (16)	0.58	32 (24)	36 (26)	0.11

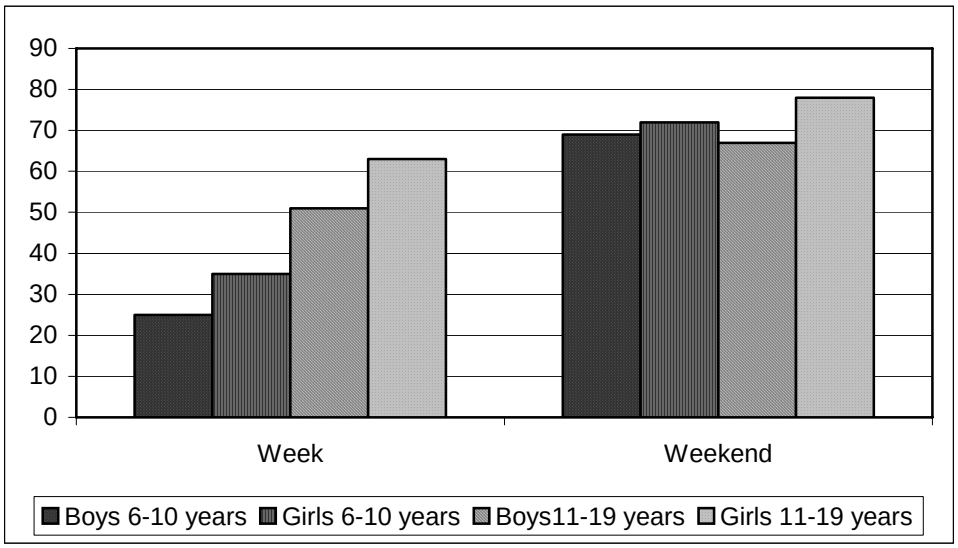
[1]Independent sample t-test [2]Moderate activity is defined as activity of 3-6 mets [3] Vigorous activity is defined as activity of more than 6 mets

Table 2 Clinical and diet characteristics (mean (SD) or number (%)) by tertiles (T1-T3) of minutes spent on moderate and vigorous activity.

	6-10-year-olds				11-19-year-olds			
	T1 (31)[1] n=74	T2 (65)[1] n=86	T3 (139)[1] n=80	p	T1 (10)[1] n=148	T2 (48)[1] n=174	T3 (111)[1] n=161	p
Male n (%)[2]	30 (41)	41 (48)	50 (63)	0.02[3]	67 (45)	89 (52)	98 (61)	0.02[3]
Age (years)[4]	8.2 (1.5)	8.5 (1.3)	8.2 (1.3)	ns	14.8 (2.0)	13.5 (2.1)	13.3 (1.9)	<0.001
Puberty (Tanner's score)[4]	1.1 (0.2)	1.2 (0.6)	1.2 (0.6)	ns	3.9 (1.2)	3.2 (1.4)	2.7 (1.4)	<0.001
HbA1c (%)[4]	7.6 (0.7)	7.7 (0.9)	7.5 (0.9)	ns	8.2 (1.4)	8.0 (1.2)	8.1 (1.2)	ns
Diabetes duration (years)[4]	3.7 (2.7)	3.1 (2.0)	3.1 (2.0)	ns	5.9 (4.0)	5.2 (3.2)	4.8 (3.1)	ns
Insulin dosage (U/kg)[4]	0.8 (0.3)	0.8 (0.3)	0.9 (0.4)	ns	1.0 (0.4)	0.9 (0.4)	0.9 (0.3)	0.03[3]
Insulin regime:								
1-2 injections n (%)[3]	2 (4)	4 (6)	5 (8)		3 (3)	6 (4)	4 (3)	
3 injections n (%)[3]	14 (26)	12 (19)	16 (27)		7 (7)	17 (13)	18 (15)	
4-6 injections n (%)[3]	19 (35)	25 (39)	19 (32)		57 (55)	59 (43)	59 (48)	
Pump users n (%)[3]	19 (32)	23 (36)	20 (33)	ns	37 (36)	54 (39)	42 (34)	ns
BMI (kg/m^2)[4]	18.0 (3.8)	17.3 (2.3)	17.5 (2.3)	ns	21.3 (3.5)	20.4 (3.7)	20.3 (3.4)	0.02[3]
Overweight n (%)[3,5]	18 (26)	14 (17)	14 (18)	ns	35 (25)	46 (27)	28 (18)	ns
Systolic blood pressure (mmHg)[4]	108 (10)	106 (14)	106 (8)	ns	118 (13)	115 (12)	116 (11)	ns
Diastolic blood pressure (mmHg)[4]	63 (8)	60 (7)	62 (7)	ns	67 (10)	66 (8)	64 (7)	0.03[3]
Serum LDL-cholesterol[4]	2.4 (0.5)	2.5 (0.7)	2.3 (0.6)	ns	2.4 (0.6)	2.5 (0.7)	2.4 (0.7)	ns
Serum HDL-cholesterol[4]	1.7 (0.5)	1.7 (0.4)	1.7 (0.4)	ns	1.6 (0.4)	1.7 (0.4)	1.7 (0.4)	ns
TV viewing (min/day)[4]	104 (49)	105 (45)	101 (42)	ns	141 (72)	130 (52)	122 (52)	0.02[3]
Skipping meals often n (%)[3,6]	1 (1)	2 (2)	1 (1)	-	27 (18)	13 (8)	8 (5)	<0.001
Snacking events seldom n (%)[3,7]	65 (88)	73 (85)	65 (81)	ns	98 (68)	135 (79)	133 (83)	0.01[3]

[1]Mean time in minutes spend on moderate to vigorous activity in this tertile. [2]Chi square [3]Not significant after correction according to Bonferroni [4]ANOVA [5]Overweight and obesity are defined according to Cole et al (2000) with self reported height and weight [6]"Skipping meals often" refers to skipping at least 7 main meals a week [7]"Having snacking events seldom" refers to having between meals two times or less during the day.

Figure 1 Percentage of participants who do not fulfil the recommendation of 60 minutes per day at a moderate and vigorous intensity level on week days and weekend



Significant difference between the numbers not fulfilling the recommendations on week days and weekend days were observed for young boys ($p<0.001$) and girls ($p<0.001$) and adolescent boys ($p<0.001$) and girls ($p<0.001$) (Pearson chi-square test).

Table 3 Odds ratio (95%CI) for being overweight (n=682)

	n1/n2[1]	OR (95%)	P
Age		0.98 (0.92-1.05)	0.54
Gender			
Boys	79/281	1.0	
Girls	76/258	0.87 (0.60-1.28)	0.48
TV viewing week days			
<1 hour	17/120	1.0	
1-2 hours a day	76/230	2.52 (1.40-4.54)	0.002
>2 hours	61/182	2.30 (1.25-4.24)	0.01
Moderate and vigorous activity			
1. tertile (17)[2]	53/157	1.0	
2. tertile (54) [2]	60/190	0.99 (0.63-1.55)	0.97
3. tertile (120) [2]	42/192	0.70 (0.43-1.13)	0.14
Breakfast			
0-5 times a week	15/21	1.0	
6-7 times a week	140/516	0.48 (0.23-0.99)	0.05
Supper			
0-5 times a week	32/59	1.0	
6-7 times a week	122/478	0.50 (0.30-0.85)	0.01

[1]n1: number of overweight and n2: number not overweight
[2]mean minutes spent on moderate and vigorous activity in each tertile