

Physical activity and sedentary lifestyle in children with type 1 diabetes: a Multicentre Italian Study

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Abstract. *Background:* Regular Physical Activity (RPA) is one of the cornerstones of Type 1 Diabetes (T1D) therapy, but conflicting results are reported in the literature. *Aim:* To compare (RPA) and Sedentary Lifestyle (SL) among children with type 1 diabetes (T1D) and healthy peers. *Subjects and Methods:* Seven Italian paediatric diabetes centres enrolled 129 children with T1D and 214 healthy peers who were interviewed by a telephone questionnaire on physical activity level, sedentary lifestyle and clinical data. *Results:* Compared to healthy peers, children with T1D: performed the same amount of RPA, were more frequently engaged in team sports ($p=0.018$), described RPA as an enjoyable activity ($p=0.033$), not boring ($p=0.035$), a chance to spend time with peers ($p=0.033$) and to meet new friends ($p=0.016$). Children with T1D were finally used to consume less snacks during watching TV ($p<0.001$) or after physical activity ($p<0.001$). HbA1c values were not related with time spent in physical activity, in watching TV or in playing video-games. *Conclusions:* Most interviewed children with T1D are physically active and perform the same amount of exercise as their healthy peers. They demonstrate to consider RPA a source of enjoyment and sociality and not a therapeutic imposition. (www.actabiomedica.it)

Key words: type 1 diabetes, physical exercise, sedentary habits, metabolic control

Introduction

Regular Physical Activity (RPA) is one of the cornerstones of Type 1 Diabetes (T1D) therapy, after insulin and dietary management (1). The benefits attributed to a RPA include lower blood pressure and decreased cardiovascular disease risk, lower BMI and less insulin resistance, better quality of life and increased sense of well being (2, 3). Therefore, in individuals with T1D, RPA leads to a minor risk of devel-

opment and progression of diabetes-related complications (1, 4-6).

Most recent recommendations for RPA in youth suggest participation in at least one hour of moderate to vigorous daily physical activity, which would be better to increase to 90 minutes to significantly reduce insulin resistance (7, 8).

A Norwegian study found that almost 60% of children with T1D do not fulfil these international recommendations and 43% usually spend more than 2

hours per day in TV viewing (9), which it is the limit recommended by the American Academy of Pediatrics (10). The scenario does not differ among healthy peers: 1 out of 10 Italian children practices at least 60 minutes of RPA per day and only 23% spends less than 2 hours daily watching TV (11).

The level of RPA might be influenced by physiological factors (gender, age, ethnicity), psychological aspects such as positive or negative perception of sport (3, 4) or socio-cultural determinants that include support and participation in RPA of peers and parents (12, 13). Furthermore, Strauss et al. showed that a Sedentary Lifestyle (SL) supports physical inactivity (14).

Among children with T1D, sedentary habits, such as watching TV or playing video games, have been associated with poor metabolic control (15, 16), while the RPA has been related to a lower HbA1c value (17, 18). Nevertheless, conflicting results are reported in the literature (19, 20).

In this multi-centre survey we tried 1) to recognise which variables influence participation in sport of children with diabetes, 2) to evaluate how their metabolic control is affected by RPA and SL, and 3) to compare their level of RPA with that of healthy peers.

Methods

The present multicentre cross-sectional study involved 7 Italian centers for children and adolescents with T1D, and was performed between November 2009 and April 2010. Children with T1D (group 1) were enrolled according to the following inclusion criteria: informed consent and assent from parents and children, age between 11 and 13 years, Body Mass Index (BMI) <97th centile, diabetes duration >12 months. The presence of a concomitant chronic disease has been considered as an exclusion criteria. Patients recruitment was carried out during a scheduled outpatient examinations at each Diabetes centre.

All selected children with T1D were invited to involve into the study two healthy peers which have been considered as a control group (group 2). These healthy children were requested, according to the above-mentioned inclusion criteria, to provide

chronological age, a recent height and weight measured by a paediatrician, and their health condition.

In the Group 1 patients a capillary blood sample for HbA1c level determination, chronological age, diabetes duration, insulin treatment, concomitant diabetes-related complications and the occurrence of severe hypoglycaemic events (blood glucose <60 mg/dl) or diabetic ketoacidosis (DKA) during the previous 3 months were recorded during a clinic visit.

BMI was calculated in all subjects using the formula: weight (kg)/height (m²). Overweight and obesity were defined according to the international cut off points for BMI for overweight and obesity proposed by Cole et al. (21). HbA1c values were measured by DCA 2000 (Siemens/Bayer®). The inter-assay coefficient of variation (CV) between Centres was 4.5-6% with a HbA1c level of 5.2%, and 0.9-1.2% with a HbA1c level of 12.1%. Normal values ranged from 4.4 to 5.9%.

The study was approved by the Ethical Committee of the University of Parma, Italy.

A questionnaire on RPA and SL habits was administered by phone to all participants to the study by trained residents. The questionnaire used was derived from the questionnaire developed by the "Centres for Disease Control and Prevention" (Iowa State University, IA, USA) validated to estimate the effects of RPA in children 9-13 years old (22). The questionnaire was translated from English into Italian, followed by an independent backward translation into English. Subsequently, the translation was endorsed by the originators and finally validated.

The questionnaire showed 2 sections. The first section (Section 1) consisted of questions concerning children participation in RPA during the 7 days before the interview, including frequency of physical activities, list of trained sport, and whether the activities were organized or practiced during free time; these "occasions" were used to calculate activity levels for the population. As previously described (11), the participation in RPA during the day before the interview was considered as a predictor of being physically active. Moreover children were asked about parents attitudes and beliefs about exercise. Physical activity was estimated as the number of days being physically active for more than 60 min. We had not the possibility of

making objective measurements of physical activity levels using accelerometers or other methods.

The second section (Section 2) inquired about sedentary and nutritional behaviour in the 7 days before the interview. Children were asked how much time daily they usually spent watching TV, playing video games, and doing homework. Sedentary behaviour was assessed from the total hours watching television during 1 week and the total number of hours being in front of computer.

The questionnaire was completed with an extra-section (Section 3) reserved to the Group 1 patients on: daily amount of time spent in RPA, daily blood glucose measurements, frequency of insulin adjustment, usual site of insulin injection, and potential modification of site injection or insulin dose before RPA. This section was filled in during the scheduled out-patient clinic visit.

Statistical analyses

The data collected were analysed using Sas version 8.2 (SAS Institute Inc, 2001) and expressed as mean±SD or percentages, as appropriate. Descriptive statistics for categorical variables were calculated using Student's t-test or Wilcoxon test and results were given as absolute frequencies and percentages.

Pearson's correlation coefficient was used to evaluate the linear correlation and linear regression model was used to assess the relationship between children's HbA1c and time spent watching TV, playing video games and doing school homework.

The χ^2 test was used to evaluate the differences between categorical variables.

Differences were considered significant if $p < 0.05$.

Results

Sample characteristics (Table 1)

A total of 343 children met the inclusion criteria for this study. There were 156 boys and 187 girls ranging in age from 10 to 13 years. One-hundred and twenty nine (37%) children with T1D (53% girls) were included in the group 1, and 214 healthy control peers (56% girls) in the group 2. The participants were classified as normal-weight (70%), overweight (24.5%) or obese (5.5%); no difference was found in BMI between groups 1 (20.53±3.16) and 2 (20.33±3.29 BMI; $p=0.575$). A total of 87 children refused to be involved in the study.

Group 1 patients

Mean diabetes duration was 5.58±2.84 years, mean daily insulin dose was 0.91±0.26 IU/kg body weight, and mean HbA1c value was 8.11±1.26%. None of the children showed diabetes-related complications.

Insulin requirement was higher in girls than in boys (0.98±0.25 IU/kg vs 0.81±0.25 IU/kg; $p < 0.001$). Insulin administration by pump was used by 18 patients (14%); conventional treatment with multiple daily insulin injections (96% by pen injectors) was used by 86% of patients. Insulin injection sites were: the back of the upper arms (40%), abdomen (38%), thighs (12%), and buttocks (9%).

Most children (36.5%) checked blood sugar 4 times per day ("twice": 6%; "3 times": 15.5%; "5 times": 18%; "6 times": 8.5%; "more than 6 times": 10%; "non respondent": 5.5%).

Table 1. Characteristic of study population (*)

	Group 1	Group 2	p value
M/F	61/68	95/119	ns
Age (yr)	12.13±0.76	12.18±0.75	ns
Weight (kg)	49.1±9.7	48.9±9.5	ns
Height (cm)	154.3±7.7	154.9±8.9	ns
BMI (kg/m ²)	20.53±3.16	20.33±3.29	ns
Overweight/Obese	33 (25.5%)/5 (4%)	52 (24%)/14 (6.5%)	ns

Abbreviations: BMI, body mass index; ns: not significant.

(*) Data are given as mean±SD or percentage (%) as appropriate

No difference was found in HbA1c values between boys (8.17 ± 1.26 %) and girls (8.06 ± 1.26 %; $t=0.489$; $p=0.625$). HbA1c values were inversely correlated with the daily frequency of blood glucose measurements ($r=-0.25$; $p=0.006$).

Throughout the 3 months before the questionnaire administration, at least one episode of severe hypoglycaemia occurred in 18 children (14%), only one required a hospital admission; and 3 children (2.3%) were admitted to the hospital because of a DKA.

Questionnaire

1 - Physical Activity

Sixty per cent of group 1 patients and 59% of group 2 children referred to participate in RPA without difference between groups ($p=0.289$; $p=0.977$).

In groups 1 and 2, children performed a similar amount of RPA (Table 2). In particular, group 1 patients were physical active for an average of 76.17 ± 49.42 minutes per day; 84% of them reported being active 60 minutes or more per day. Girls told practicing less (<60 min) than boys (26% vs 2%; $p<0.05$).

Group 1 patients as well the group 2 children preferred soccer (32.7 vs 32 %), volley (25.3 vs 24 %), gym (19.8 vs 15.9 %), and swimming (16.5 vs 17.4 %) , but the patients of group 1 were engaged in team sports more frequently than those included in the group 2 children (67.5% vs 55%; $p=0.018$).

The majority of patients of group 1 (82%) reported to be able to perform all kind of sports. Unlike group 2 healthy controls, children with T1D described RPA as an enjoyable activity (79.1% vs 69.6%;

$p=0.033$), not boring (73.5% vs 65%; $p=0.035$), a chance to spend time with peers (88.5% vs 80%; $p=0.033$) and to meet new friends (88.5% vs 80%; $p=0.016$), without limiting personal interests (66% vs 53.5%; $p=0.036$).

Fifty per cent of group 1 patients declared to “never” modify insulin injection site before exercising (“always”: 13%; “sometimes”: 20%; “doesn’t know”: 17%) and 51% “never” to reduce insulin dose (“always”: 20%; “sometimes”: 29%).

From children’s point of view, parents of group 1 were more satisfied than those of group 2 to see their children doing sport (92% vs 84.5%; $p=0.008$), and were more inclined to join them in RPA (53% vs 38%; $p=0.013$).

No correlation between HbA1c values and daily amount of RPA ($r=0.20$; $p=0.065$) was found. On the contrary an inversely relation between time spent doing homework and HbA1c levels was observed ($r=-0.30$; $p=0.004$).

2 - Sedentary Behaviours

Table 3 provides the amount of time spent in sedentary activities during the 7 days before the interview: no differences were found between group 1 and group 2. Sedentary activity was mainly dedicated in watching TV or playing videogames in both children groups without significant differences between groups (Table 3). The habits to watch TV is sustained by having a TV set in the bedroom (836.50 ± 806.98 vs 679.90 ± 692.23 min/week; $p=0.035$)

TV viewing during meals was widespread: 73% of total children watched TV during lunch and 81% during dinner (31% during breakfast), with no differences

Table 2. Profile of the and physical activities in children with diabetes (group 1) and in healthy peers (group 2) (*)

	Group 1	Group 2	P value
Physical exercise			
Occasions/week	7.01 ± 6.52	5.92 ± 5.31	0.278
Min/day	517.4 ± 616.36	517.09 ± 613.78	0.075
Session time	72.75 ± 30.66	85.74 ± 48.03	0.932
In the day before the questionnaire	34%	41%	0.289
In the 7 days before the questionnaire	79%	79.5%	0.977

Abbreviations: Min=minutes.

(*) Data are given as mean \pm SD or percentage (%) as appropriate

Table 3. Profile of the sedentary in children with diabetes (group 1) and in healthy peers (group 2) (*)

	Group 1	Group 2	P value
Sedentary activities			
TV viewing			
- N day/week	5.72±1.92	5.94±1.60	0.886
- Min/day	113.68±92.82	134.36±128.28	0.268
TV during mealtimes			
- Breakfast	40%	26%	
- Lunch	74%	70.5%	0.213
- Dinner	79%	83%	
TV in bedroom	67.5%	57.5%	0.088
Video-games playing			
- N day/week	3.94±2.70	4.02±2.51	0.859
- Min/day	94.44±74.39	103.84±101.95	0.752
Music listening			
- N day/week	5.13±2.15	5.28±2.10	0.587
- Min/day	73.05±76.83	69.63±67.66	0.721
Reading			
- Min/week	92.80±131.68	109.65±114.94	0.318
Homework			
- Min/day	410.22±142.62	403.11±140.99	0.323
How do you reach the school?			
	Car 48%	Car 31%	
	Bike 5%	Bike 3%	
	Bus 17%	Bus 23.5%	0.010
	Foot 29%	Foot 41%	

Abbreviations: N=number; Min=minutes.

(*) Data are given as mean±SD or percentage (%) as appropriate

between groups ($p=0.512$ and $p=0.257$ respectively). Children of group 1 were not used to eat snacks during TV viewing, while this habit was more common among healthy peers (18% vs 55%; $p<0.001$).

HbA1c values were not related with time spent watching TV ($r=0.13$; $p=0.152$) or playing video-games ($r=0.09$; $p=0.382$), or snacking in front of the screen ($p=0.603$).

Discussion

The aims of the present study were to compare RPA and SL in a large cohort of Italian children with T1D and in healthy peers, and to evaluate which fac-

tors could influence RPA adherence and metabolic control in children with T1D.

Our study shows that most interviewed children with T1D are physically active and perform the same amount of exercise as their healthy peers. Their participation in sports is similar to that recently released by the Italian Institute of Statistics indicating that about 59% of youth between 6 and 17 years of age regularly or occasionally engage in one or more sporting activities. Our finding differs from that of other Authors who report only 25% of T1D patients able to reach a good level of RPA (18). The difference might be interpreted as an improvement in the socialisation process experienced by the children with T1D engaged in the study. This speculation is also supported

by the finding in the same sample that diabetes status seems not to represent a barrier to perform popular sports like soccer, volley and gym, and to be engaged in team sports where exercising likewise their peers. It is not then surprising if children with T1D consider exercising an enjoyable occasion to stay with peers and to meet new friends. This way to approach physical activity produce in a great part of children with diabetes feelings of well-being, less worries and finally a general perception of good quality of life, as also reported by other Authors (23). This psychological well-being preferably concerns boys than girls, confirming that many girls develop early in adolescence a decline in both quality of life (24) and RPA levels (25).

This advanced participation in sports does not agree with a poor attitude in diabetes management during exercise. More than 50% of children with T1D reported not to modify the insulin dose or injection site before exercising, despite most of them are used to check blood glucose level more than 4 times a day, and are inclined to inject one or more insulin additional doses to correct a hyperglycaemia. This inconsistency might explain the 14% of symptomatic exercise-induced hypoglycaemia reported in the weeks preceding the questionnaire administration. It is well known that physical activity is associated with improved insulin sensitivity requiring less insulin than usually (6, 17). It is thus difficult to comment the behaviour of half of the children included in this study regarding insulin adjustment before exercising. A possible explanation is that these children are not used to programme a physical activity and therefore to reduce in advance insulin doses and to choose a more convenient site for injection. These children need probably an education supplement on diabetes management.

Our results fail to show that daily amount of RPA influences the HbA1c levels. This datum partially contradicts our previous survey where we reported that HbA1c levels were better in motivated patients than in children exercising sporadically and shortly (26). About the relationship between physical activity and glycemic control in T1D patients conflicting opinions are generally reported. Some Authors found that glycemic control is not associated with physical activity and particularly physical activity do not negatively affect glycaemia control (27, 28). Others suggest

that patients who exercise in the morning may achieve lower blood glucose and fructosamine levels than their active peers (28). Controlled studies have not been able to show better diabetes control due to physical activity, so exercise can not be considered as a treatment for diabetes (29). Anyway, since exercise is an effective method to improve metabolic control and other clinical parameters (28,30), children and adolescents with T1D should be encouraged to exercise and to pursue their interest in whichever sport they enjoy (26).

A surprising result of our study is the inverse relationship between time spent doing homework and HbA1c levels. In general, any relationship between them is reported (19,31). In agreement with other Authors we can speculate that this might reflect the association between personality and health (25), and the habits of children with T1D to perform RPA before or after homework. The explanation of this finding is more complex and needs further evaluation.

In our population, without difference between groups, physical activity is partially affected by sedentary habits such as TV viewing or video-games playing, although more than 60% of the children told watching TV everyday and 28% exceeded the advised limit of two hours per day (10). These data confirm a recent survey promoted in Northern Italy supporting the opinion that TV viewing has become an usual habit, equally widespread, not only among sedentary children, but also among active children (30).

Some Authors have showed an increase in HbA1c levels with every hour of watching television (9) and others have reported, but we did not find this association.

It is finally encouraging finding that fewer children with diabetes, compared to healthy peers, had snacks in front of the TV screen.

Conclusion

Our study shows that most interviewed children with T1D are physically active and perform the same amount of exercise as their healthy peers according to the international recommendations to exercise 60 minutes or more per day. They demonstrate to consider RPA a source of enjoyment and sociality and not a

therapeutic imposition. Positive attitude towards physical activity and healthy dietary habits found in children with T1D may be considered as the result of a continuous medical education given to children and family. Therefore, more educational efforts should be carried out about diabetes management during exercising.

Acknowledgements

Thanks go to doctor Rossana Di Marzio for the manuscript revision and to Abbott Diabetes Care-Italy for its support.

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Accepted: April 5th 2011

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