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Original Article

Target setting in intensive insulin management is associated with metabolic control: the Hvidoere Childhood Diabetes Study Group Centre Differences Study 2005

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Objective: To evaluate glycaemic targets set by diabetes teams, their perception by adolescents and parents, and their influence on metabolic control.
Methods: Clinical data and questionnaires were completed by adolescents, parents/carers and diabetes teams in 21 international centres. HbA1c was measured centrally.
Results: A total of 2062 adolescents completed questionnaires (age 14.4 ± 2.3 yr; diabetes duration 6.1 ± 3.5 yr). Mean HbA1c = 8.2 ± 1.4% with significant differences between centres ($F = 12.3$; $p < 0.001$) range from 7.4 to 9.1%. There was a significant correlation between parent ($r = 0.20$) and adolescent ($r = 0.21$) reports of their perceived ideal HbA1c and their actual HbA1c result ($p < 0.001$), and a stronger association between parents' ($r = 0.39$) and adolescents' ($r = 0.4$) reports of the HbA1c they would be happy with and their actual HbA1c result. There were significant differences between centres on parent and adolescent reports of ideal and happy with HbA1c ($8.1 < F > 17.4$; $p < 0.001$). A lower target HbA1c and greater consistency between members of teams within centres were associated with lower centre HbA1c ($F = 16.0$; $df = 15$; $p < 0.001$).
Conclusions: Clear and consistent setting of glycaemic targets by diabetes teams is strongly associated with HbA1c outcome in adolescents. Target setting appears to play a significant role in explaining the differences in metabolic outcomes between centres.

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The Hvidoere Study Group (HSG) on Childhood Diabetes has investigated metabolic control in large cohorts of adolescents from more than 20 paediatric diabetes centres worldwide. This research has demonstrated that there are substantial differences in the metabolic outcomes between centres, the differences are relatively stable over time, they emerge early in the life course of newly diagnosed young people, are not attributable to differences in population demographics and are largely unaffected by attempts to improve outcomes by many of the centres (1–3). The most recent study confirmed that the differences are not attributable to specific insulin regimens but seem to be influenced by a centre's effectiveness in implementing treatment regimens (3).

In the HSG Centre Differences Study 2005, a wide range of psychological, social, cultural and service delivery factors have been explored which might account for the centre differences. We have reported that family dynamics are important predictors of metabolic outcomes in individual adolescents but the effects are relatively consistent across centres and, therefore, do not account for the substantial inter-centre differences (4). During the development of this study, discussion among the research group members suggested that there might be differences in the aggressiveness with which centres pursued metabolic control targets. With literature suggesting that patient goals are strong predictors of outcomes in chronic diseases (5, 6), it is possible that differences in targets set by health care professionals (HCPs) and their perception by patients might influence metabolic outcomes. In diabetes, there is a dearth of information on the relationship between professionals' and individual's goals, although one study in adults with type 2 diabetes has shown that centre differences in metabolic outcomes can be attributable partly to the differences in fasting blood glucose (FBG) targets set by physicians and GPs (7).

This paper describes the relationship between HCPs', parents' and adolescents' self-reported targets for glycaemic control, and the glycaemic outcomes in the adolescents and centres.

Research design and methods

An observational multicentre, cross-sectional study was performed between March and October 2005,

involving 21 paediatric diabetes departments from 19 countries in Europe, Japan, Australia and North America. Adolescents (aged 11–18 yr; diabetes duration >12 months), parents and HCPs were invited to participate. Each centre was limited to a maximum of 200 adolescent participants. If a centre had more than 200 eligible adolescents, only the patients seen by the one Hvidoere member were invited.

The case report form (CRF) included information on age, gender, height, weight, duration of diabetes, number of severe hypoglycaemic events (defined as seizures or loss of consciousness in the 3 months preceding blood sampling) and number of episodes of diabetic ketoacidosis (DKA necessitating hospital admission in the last year). The number of insulin injections, types of insulin and injection devices were recorded. Information was obtained on concomitant medical conditions (coeliac disease, thyroid disease, epilepsy, asthma or other). As a marker for ethnicity/minority group status, the CRF recorded whether there were language difficulties leading to communication problems with the diabetes team.

All HCPs within each diabetes team completed a questionnaire. They were asked 'What do you consider as the most realistic and practical targets for HbA1c?' They were invited to give their responses for three age groups: 0–5, 6–10 and 11–18 yr, with five response options available (<7.0; 7.0–7.4; 7.5–7.9; 8.0–9.0% or no specific target). Only their responses for the 11–18 age group are analyzed here.

The adolescents and parents completed comprehensive questionnaires and were asked two specific questions 'About your long term sugar test, HbA1c, what do you think the ideal result should be?' and 'What result would you be happy with today?' The responses available were the same as for the HCPs, with the exception that 'no specific target' was replaced with 'do not know'.

A capillary blood sample was provided by participants and analyzed at Steno Diabetes Centre, Gentofte, Denmark. HbA1c was DCCT aligned (normal range 4.4–6.3%, mean 5.4% and an inter-assay SD of 0.15% by the *Tosoh method*). Details of transportation and stability of specimens have been published (1). The study was performed according to the criteria of the Helsinki II Declaration and was approved by the local Ethics Committee at each centre.

Statistical analysis

Data were all double entered at a central administration centre, and ambiguous data on the CRF were resolved by direct contact with participating centres. All analysis was completed using SPSS v15. Two group comparisons were conducted using simple independent *t*-tests, where Levene's tests showed non-equal variance between groups, the appropriate corrected t and p values are cited. Associations between individual targets (adolescent and parent) and HbA1c were tested using analysis of variance, with planned comparisons. Correlations between ordinal variables were conducted using Spearman's ρ correlation coefficient, for mixed level data using Kendall's τ and for parametric data using Pearson's product moment coefficient (with all report results being significant at $p < 0.001$, unless otherwise stated). In multiple regression analysis to predict HbA1c, insulin regimens were dummy coded, with demographic and medical characteristics entered using stepwise entry.

Results

A total of 2269 eligible individuals attended clinics during the recruitment period. Of these, 2062 (91%) adolescents completed a questionnaire and 2036 (90%) provided a blood sample for assay.

Mean HbA1c = 8.2 ± 1.4% with significant differences between centres ($F = 12.3$; $p < 0.001$) range from 7.4 to 9.1%. Details of the sample demographics have been reported elsewhere, but the sample providing blood samples had a shorter duration of diabetes (3). There were no other significant differences for demographic or medical characteristics.

A total of 152 HCPs completed the team members' questionnaire, with no missing responses. Most of the respondents were paediatric physicians (46%) and paediatric specialist nurses/educators (32%). Of the 21 centres, 6 did not have a dietitian, 11 had no psychosocial-orientated health professional, with 3 centres having both a psychologist/psychiatrist and a social worker as part of the care team. There were no differences in metabolic outcome between centres with or without a psychologist, but centres with dietitians had adolescents with poorer HbA1c (no dietitian n = 573, mean = 8.0%, SD = 1.3; with dietitian n = 1463, mean = 8.3%, SD = 1.4, $t = -4.02$, $p < 0.001$) but not for other metabolic outcomes (hypoglycaemia or DKA). There was no relationship between the size of centres according to the number of adolescents treated and whether they had a dietitian, but larger diabetes teams were more likely to have a dietitian (dietitian mean number in team 8.3, SD = 4.1; no dietitian mean 4.5, SD = 1.6; $p < 0.05$).

Adolescent and parent targets

Neither parent nor adolescent reported targets were associated with age, and there were no gender differences in reported targets. Parent reported targets were not associated with duration of illness, but adolescent reported higher ideal target was associated

with longer duration ($F = 2.5$; $df = 4$; $p = 0.04$) but not for results they would be happy with. *Post hoc* analysis indicated that this was caused by individuals who reported they did not know what their ideal target was, had shorter duration of diabetes (mean = 4.3 yr SD = 3.0) than individuals who reported an answer (mean = 6.1 yr; SD = 3.5; $p < 0.001$).

Both adolescent and parent self-reported targets were associated with the actual adolescent HbA1c, see Table 1, with planned comparisons indicating a linear effect in data (in all cases $p < 0.001$). Thus, as the reported ideal target or result they would be happy with today decreased, so did actual HbA1c. However, these effects were noticeably stronger for results that adolescents and parents would be happy with today (F ratio adolescent = 138.6; parent = 131.6) than for ideal results (F ratio adolescent = 30.1; parent = 27.9). Furthermore, centre rank was significantly correlated with adolescent (ideal $r = 0.28$; happy $r = 0.33$) and parent (ideal $r = 0.27$; happy $r = 0.33$) reported targets for HbA1c.

Diabetes team member's targets

Table 2 provides a graphical summary of the diabetes team members reported target HbA1c for adolescents, ranked in order of centre HbA1c. From this table, it would appear that centres targeting lower HbA1c's tend to have adolescents with better metabolic control and that centres with greater agreement among professionals tend to have adolescents with lower HbA1c levels. This was tested using ANOVA, with the mean centre target ($F = 16.0$; $df = 15$; $p < 0.001$; $\eta^2 = 0.11$), median centre target ($F = 145.3$; $df = 3$; $p < 0.001$; $\eta^2 = 0.06$) and the variance in centre target ($F = 14.1$; $df = 13$; $p < 0.001$; $\eta^2 = 0.08$) all associated with actual centre HbA1c, with the effect of centre rank being of an equivalent effect size ($F = 12.4$; $df = 20$; $p < 0.001$; $\eta^2 = 0.11$).

Further analysis indicated that the teams treatment target is correlated with adolescent (mean ideal $r = 0.28$; median ideal $r = 0.26$; mean happy with $r = 0.30$; median happy with $r = 0.31$) and parent (mean ideal $r = 0.28$; median ideal $r = 0.26$; mean happy with $r = 0.34$; median happy with $r = 0.35$) reported targets, with these correlations being comparable to associations with centre ranked HbA1c status (see above). Further support for the association is evident from the fact that both the team mean and median target HbA1c is correlated with actual HbA1c (mean $r = 0.20$; median $r = 0.21$). Thus, in centres where professionals reported lower target HbA1c, both adolescents and parents were more likely to report lower target HbA1c.

Centre differences in outcome

Given the relationships among adolescent, parent and HCP treatment targets and centre ranks, these data were correlated with individual HbA1c, and multiple regression analysis was undertaken to determine whether these differences in metabolic targets account for the differences between centres. On step 1 of the regression, demographic and medical variables associated with metabolic control along with centre rank were entered (3). On step 2, adolescent and parent reported targets, along with the team target variables (mean target, median target, variance in target and interaction term for variance by mean) were entered, on a stepwise basis. The results of this regression can be seen in Table 3. Demographic and medical characteristics accounted for 6% of variance in HbA1c. Centre rank, entered on step 2, accounted for a further 11% of variance on step 2. However, the addition of adolescent reported targets and the result parents would be happy with, along with interaction term for mean team target by variance in target, entered the regression model on step 3. The addition of these target variables increased the total variance accounted for by the model to 33%. However, of note is that on entering the treatment target variables, the effect of centre rank is further reduced and only accounts for 3% of the variance in HbA1c in

Table 1. Number of adolescents and parents reporting HbA1c targets and mean HbA1c with standard deviation

Reported targets		<7.0	7.0–7.4	7.5–7.9	8.0–9.0	Do not know
Adolescent ideal	N	*975*	*713*	*205*	*25*	*47*
	Mean	7.9	8.4	8.8	8.9	8.1
	SD	1.4	1.3	1.3	1.0	1.6
Adolescent happy	N	*639*	*691*	*473*	*141*	*13*
	Mean	7.4	8.1	8.6	9.6	10.5
	SD	1.2	1.2	1.2	1.5	2.1
Parent ideal	N	*1056*	*627*	*189*	*18*	*31*
	Mean	7.9	8.3	8.9	8.9	8.4
	SD	1.3	1.3	1.3	1.3	2.3
Parent happy	N	*600*	*694*	*466*	*127*	*18*
	Mean	7.5	8.0	8.7	9.6	10.6
	SD	1.3	1.1	1.1	*1.4*	2.0

Table 2. Percentage of professionals in each centre team reporting HbA1c target range for centre

Centre mean HbA1c (SD)	Target <7.0 (%)	7.0–7.4 (%)	7.5–7.9 (%)	8.0–9.0 (%)	No specific target (%)	Number of team members completing	Number of adolescents completing
7.4 (1.1)	100					8	142
7.6 (1.1)	100					3	124
7.7 (1.1)	20	40.0	40			5	68
7.7 (1.2)		100				5	129
7.8 (1.1)	17	83				6	191
7.9 (1.1)			57	43		7	104
8.0 (1.4)	53	43	6			22	192
8.0 (1.2)		100				2	28
8.1 (1.2)		100				7	84
8.2 (1.2)		60	40			6	78
8.2 (1.1)		40	40	10	10	10	200
8.2 (1.3)	33	44	22			10	100
8.3 (1.2)	20.0	60		20		5	78
8.4 (1.7)		60	20	20		5	119
8.4 (1.3)		80	20			7	92
8.6 (1.6)		20	20	60		7	65
8.8 (1.7)		33	44	22		9	101
8.8 (1.6)				100		6	66
8.8 (1.2)			75	25		9	86
9.0 (1.4)			60	20	20	8	109
9.1 (2.0)		20	60	20		5	113

Table 3. Results of multiple regression to predict HbA1c

	Beta	t	P
Step 1			
Age	0.069	3.077	0.002
Gender	−0.054	−2.517	0.012
Duration of diabetes	0.123	5.432	0.000
Insulin dose (U/kg/24 h)	0.139	6.414	0.000
Insulin regimen (twice daily free mix)	0.050	2.247	0.025
Centre rank	0.337	15.251	0.000
Step 2			
Age	0.041	2.025	0.043
Gender	−0.060	−3.136	0.002
Duration of diabetes	0.066	3.236	0.001
Insulin dose (U/kg/24 h)	0.090	4.627	0.000
Insulin regimen (twice daily free mix)	0.047	2.362	0.018
Centre rank	0.164	7.596	0.000
Adolescent reported result 'happy with'	0.298	11.910	0.000
Parent reported result 'happy with'	0.244	10.339	0.000
Adolescent reported 'ideal' result	−0.060	−2.757	0.006
Team target interaction term	−0.096	−2.728	0.006

the final model. This indicates that differences in treatment targets reported by adolescents, parents and team members at least partially accounts for the differences seen between treatment centres. Furthermore, it is also of note that the effect of age is noticeably reduced by the addition of the treatment target variables.

Discussion

This study in a large cohort of adolescents has shown strong correlations between the self-reported glycaemic targets by the adolescents and their parents, and also those set by diabetes HCP teams and actual metabolic outcome. The team outcome is strengthened if there is consistency in the targets set between various members of the team. These findings appear to be the most influential so far uncovered in the search for factors that are responsible for the substantial and persistent differences in metabolic control between centres in the HSG (1–3).

This raises the question as to how goals expressed by HCPs apparently have such an impact on adolescent and parent goals and subsequent control. One possibility is that teams that set higher HbA1c goals are more concerned about the increased risks of severe hypoglycaemia with intensified therapy (8). Perhaps, they see a stronger relationship between glycaemic control and hypoglycaemia, and/or see hypoglycaemia as more adversive than teams which set lower goals. This would make them more willing to compromise on glycaemic targets. This might be an influential mechanism acknowledging the fear that hypoglycaemia engenders in parents (9, 10). However, it would seem unlikely as in this study we have seen no relationship between rates of hypoglycaemia and centres or insulin regimens (3), and in a previous study the centres with more optimal glycaemic control tended also to have lower hypoglycaemia rates (2).

Alternatively, teams focused on avoidance of hyperglycaemia might set lower targets but they would also need to believe that these are achievable by the young people, and convey this to families. This belief may help to instil confidence, thus increasing the time and effort in pursuing lower targets, both in HCPs and in the adolescents and their carers, making it more likely that they are successful in achieving their goals.

However, it should be noted that the regression analysis highlighted that it was the interaction terms between target and variability of target that predicted HbA1c. If the regression is repeated without this interaction term (median target and variability independently added), only variation in target across teams predicts HbA1c. Thus, it may be that teams, which do not agree on treatment goals, do not create confident working relationships with families, and both the adolescents and parents recognize these inconsistencies between team members.

It is interesting to note that several educational reviews and guidelines on children and adolescents make little or no mention of target setting being of importance (11–13), whereas others mention targets but without supportive evidence (14–17). In the American Diabetes Association and Australian paediatric clinical practice guidelines, there are sections devoted to glycaemic goals but without references to provide evidence that setting such goals for individuals has any relevance or efficacy (16, 18). A study in adults with type 2 diabetes in Italy found that only 14% of diabetologists and family practitioners used specific targets for FBG, and the target levels adopted were extremely heterogeneous (7). In those patients who were always seen by the same physician, when the target FBG was $\leq$6.1 mmol/L, the group HbA1c was 7.0%, whereas when the target FBG was $\geq$7.8 mmol/L the HbA1c was 7.8%. Were these results produced as a consequence of seeing the same doctor consistently in accordance with the motivating physician's wishes or did the target setting itself invoke a better outcome?

Is there any evidence, in the paediatric literature, that targets for HbA1c influence outcomes? Schwartz and Drotar (6) suggest that there is remarkably little research on goal setting in childhood chronic illness, using the available literature to provide a framework for developing research in this area. Of interest is that in discussing a potential change in the global standards and reference range for glycated haemoglobin, an intriguing experience was reported from a centre in Sweden (19). The glycated haemoglobin reference range changed twice in opposite directions. When the reference range was raised, it resulted in childrens' average HbA1c unexpectedly drifting downwards towards the previous range and drifting upwards again when the reference range was lowered. The author suggested that when the targets were changed, there was for a period of time a target memory that pushed levels towards the previous target.

Clinical experience suggests that excellent glycaemic control is 'significantly related to the frequency of clinic attendance (six to nine times per year)' when 'HbA1c is measured at every visit and the patients know the result and the target' (20). However, there is no evidence that the target setting *per se* has significant influence.

In diabetes management, goal setting has been highlighted as being important in guided self-determination, helping patients to develop life skills and to improve glycaemic control (21). Determination is one of the key sequences in the process of change, which in itself is essential in the lives of most people with diabetes (22). Also other research focussing on patients' descriptions of autonomy support from HCPs (23) may well influence these processes leading from goal setting to guided self-determination and then to changed behaviour resulting in an improvement in achievement. Despite this theoretical background, in the field of diabetes, there has been scant regard for actually testing the effects of goal setting.

How should our results be interpreted? On both an individual and centre basis it might be argued that because an adolescent or a centre has consistently achieved lower HbA1c levels, they will tend to report lower figures as their targets. This might even explain to some degree the consistency of reports from team members from successful centres and also the parents and adolescents. What comes first – are the lower targets in themselves conducive to better achievements in adolescents or are the consistently better outcomes in certain centres simply reflected in reports of lower targets?

If targets and goals are seen as the drivers towards change and improved achievements, then our results would appear to be consistent with that hypothesis. Target setting appears to be an important facet of the whole successful implementation package of intensive management by an integrated consistent diabetes team, based not so much on treatment regimens themselves but on team attitudes and behaviour towards better diabetes outcomes. When the HSG looked at the influence of specific insulin regimens on centre differences, it was found that although a twice daily free mixing insulin regimen was associated with the lowest HbA1c, this was not because of the regimen itself but the way in which that regimen was implemented in certain centres (2, 3, 20). Some centres are better than others at using several of the regimens. It now appears from this study that the better centres with lower HbA1c are also more successful at educating the parents and adolescents not only in understanding the levels of glycated haemoglobin which are desirable but also providing an environment which enables those targets to be achieved.

If specific glycaemic targeting is important in diabetes what are the mechanisms which make it work? There appears to be widespread agreement that to set unattainable goals may lead to feelings of failure and learned helplessness or powerlessness in many individuals (24). Our data seem to contradict this idea because the targets set in the centres which achieve the best results would seem to be impossible to achieve in many of the less successful centres. We are aware that our data, collected from all members of each centre team cannot inform us of why particular teams or team members report such variable targets. Moreover, the unique influence of individual members has not been explored. This would require a far more in-depth investigation of team dynamics, which was beyond the scope of the current study. It has been widely recommended and emphasized that diabetes care is optimized by having a multidisciplinary team (25–28). We have not found an association between glycaemic control and the numbers of HCP within teams. It is difficult to understand our finding that the adolescents in centres without a dietitian have slightly lower HbA1c, although this may be a reflection that these are smaller teams, who may be more cohesive and have more agreement around treatment decisions. There is an abundance of behavioural science literature mainly from North America which emphasizes the importance of patient empowerment, the development of collaborative self-management, including clarification of goals, and is heavily critical of the physician-centred medical mode of education (29, 30). However, in several of the better centres in this study, it would appear that they are organized very much on a physician-centred education process so much so that at least one has minimal input from nurses in clinic education and another has no dietitian. Therefore the mechanisms by which certain teams attain greater success in association with setting targets of glycaemic control remain open to debate and evaluation. Perhaps they have a grounding in the cultural environment in which the clinic resides as previously suggested in an earlier HSG study (31).

In conclusion, we have found a close association between the targets for glycaemic control perceived by adolescents and parents and those set by paediatric teams. Moreover, if members of the teams are consistent in their advice on targets, the adolescent HbA1c correlates with those targets. Target setting appears to be the most influential factor in explaining centre differences in metabolic control in our studies.

In the management chronic diseases such as diabetes, clear, consistent messages and targets should be provided for young people and their carers.

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Conflicts of interest

All members of the HSG receive funding from Novo Nordisk used only for the research studies and travel expenses to the Hvidoere Annual Meeting in Denmark. There are no other potential conflicts of interest.

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