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EDITORIAL

Lifestyle Modifications in the Management of Type 1 Diabetes: Still Relevant After All These Years?

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As we progress into the 21st century, the landscape of research and treatment in type 1 diabetes (T1D) is undergoing a massive transformation, characterized by rapid advances on numerous scientific fronts, including insulin and other hormonal therapies, technologies for blood glucose (BG) monitoring and insulin delivery, stem cell therapies, genetic engineering, β-cell transplantation, and even xenotransplantation. Clearly, these scientific advances have enormous implications for future diabetes management. These rapid developments and cutting-edge discoveries may also have important, but not always obvious, implications for our perspectives on how different aspects of diabetes management should be prioritized in research and patient care. For example, with the enthusiasm generated by recent technological breakthroughs, especially those associated with closed-loop control (CLC) or the artificial pancreas (AP), is there a reason to be concerned that more traditional (and perhaps less ''exciting'') aspects of T1D management, such as lifestyle modifications, will receive less attention in research and diabetes care? How relevant are lifestyle factors, including diet and exercise, to contemporary views and practice of T1D treatment? What role will they play in future diabetes management? This column explores the potential impact of recent scientific advances on attitudes regarding the importance of lifestyle modification in T1D treatment, as well as the possibility that there is a growing tendency to undervalue their role as essential determinants of clinical outcome.

For both T1D and type 2 diabetes (T2D), lifestyle modification has always been, and remains, one of the most formidable tasks in diabetes management. It is somewhat surprising that there is evidence that dietary as well as physical activity habits are actually poorer in both youth and adults with T1D than their peers without diabetes.[1–5] For this reason, it is appealing to envision a future in which technology, such as CLC systems, would offer a solution to the problem of lifestyle modification. The primary goal of automated glucose control is, of course, to benefit T1D individuals (and someday those with T2D) by improving glycemic status and medical outcome.[6] Just as important, these systems have the potential to greatly improve quality of life by reducing the psychological and behavioral burden of diabetes management. Among the many burdens that living with T1D imposes, the demands of lifestyle modifications, especially the constant monitoring and/or regulation of food intake, have significant negative effects on quality of life. With CLC systems, patients with T1D can imagine being able to eat whatever and whenever they want, and engage in as much or as little exercise as they desire, all while maintaining BG levels in a safe and healthy range.

However, it is important to recognize the extent to which this automated model of glucose control radically changes the traditional paradigm of self-management of T1D, in which patient decision-making and behaviors are of paramount importance. In the extreme version of the automation paradigm, patient behavior and lifestyle will play a negligible role in diabetes management. From a technological perspective, food intake and exercise are seen as ''metabolic perturbations'' or ''disturbances'' in glucose regulation, presenting major challenges to developing CLC systems. In this paradigm, lifestyle factors are still problems, but problems that can be solved algorithmically.

Only time will tell the extent to which CLC technology can overcome the disruptive influence of patient lifestyle and behavior on T1D glucose control. There are also many possible gradations of automation, ranging from regulating only discrete aspects of glucose control, such as low BG suspension systems to prevent hypoglycemia, to controlling glucose levels fully throughout the day without need for meal or exercise announcements. Nonetheless, the history of technology in T1D treatment would predict that patient lifestyle and behavior will always be limiting factors in the ability to duplicate normal glucose metabolism through improvements in insulin delivery and glucose sensing/monitoring. One possibility is that even a fully CLC system will operate more effectively to normalize glucose control if patients are engaging in corresponding lifestyle behaviors that minimize BG dysregulation. From a psychological perspective, it also seems likely that the fully automated scenario will generate a host of new and unique behavioral challenges in T1D

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Table 1. Percentage of Publications for Treatment Key Words from 2003 to 2013 for Type 1 and Type 2 Diabetes

		Type of diabetes			
		Type 1		*Type 2*	
Key word	*Total* n	n	*% of total*	N	*% of total*
Physical Activity	2,439	238	9.8%	2,201	90.2%
Exercise	4,073	519	12.7%	3,554	87.3%
Nutrition	4,134	521	12.6%	3,613	87.4%
Diet	6,937	768	11.1%	6,169	88.9%
Carbohydrate	1,548	316	20.4%	1,232	79.6%

management. Perhaps some patients will respond to automated glucose control by engaging in riskier behaviors, such as consuming previously ''forbidden'' extremely high-carbohydrate foods or skipping meals to lose weight, which could negatively affect the performance of systems. For many reasons, it seems highly unlikely that patients' diet and exercise behaviors can ever be completely removed from the T1D treatment paradigm.

In addition to the CLC model, attitudes regarding the importance of lifestyle modification in T1D have been influenced over the past decade by the growing awareness of the causal role these factors play in T2D,[7–9] which can easily overshadow their clinical significance in T1D. Lifestyle modifications certainly cannot prevent or delay T1D, which can contribute to a perception that they are far less important in treatment. One method for exploring the relative scientific and clinical interest in lifestyle factors in T1D and T2D is to examine the number of publications addressing these issues during the past decade. To accomplish this, a PubMed search was conducted using different lifestyle key words, to compute the number of publications for T1D and T2D from 2003 to 2013. Table 1 summarizes these results, showing that for almost all key words related to lifestyle factors, roughly 90% of publications dealt with T2D. The one exception to this pattern is the key word ''carbohydrate,'' where 20% of publications dealt with T1D. Although this somewhat perfunctory investigation has obvious methodological shortcomings, these large discrepancies support the conclusion that there has been far less relative scientific interest in lifestyle factors in T1D management.

Counting publications can provide a rough estimate of scientific interest, but the most important question is whether T1D and T2D patients are receiving the highest standards of care related to lifestyle factors and their impact on diabetes outcome. To explore the existing status quo of contemporary diabetes care, a natural starting place is current treatment guidelines from leading diabetes organizations. Both the American Diabetes Association and the American Association of Diabetes Educators have published clear recommendations for lifestyle modification for T1D and T2D, although significantly more space is devoted to T2D.[10–12] None of the guidelines endorses a specific type of diet, but rather recommends that all individuals with T1D and T2D receive ongoing medical nutrition therapy (MNT), preferably from a registered dietician, as needed to achieve glucose, as well as lipid and blood pressure, goals. The objective is to provide patients with the necessary nutritional information and skills to develop and implement the diet plan that works best for them and optimizes diabetes control. For patients with T1D (and T2D using insulin), recommendations go beyond general guidelines for a healthy diet and include information and skills related to carbohydrate counting, use of insulin-to-carbohydrate ratios, behavioral strategies, and hypoglycemia treatment. (Recommendations for T1D and exercise[13] focus primarily on providing patients with tools that allow them to engage in physical activity safely without triggering hypo- or hyperglycemia and other negative effects related to long-term complications.)

So the next question of relevance is whether the diabetes community is meeting these basic standards of patient care in lifestyle modification, keeping in mind that, in this year 2014, T1D technologies are emerging that seemed impossible a decade ago, and the development of an AP appears not only possible but certain. Unfortunately, the gap between treatment recommendations and the current status of patient education is immense for both T1D and T2D, a situation that receives little attention given its potential negative impact on people living with diabetes. Studies generally agree that only about half of patients receive any diabetes education at all, with far fewer receiving MNT, especially by a registered dietician.[10,14,15] No parallel studies have investigated the rates of diabetes education in exercise, delivered by a certified specialist or physiologist, but most certainly this is even more uncommon. These dismal statistics clearly indicate that T1D patients are not receiving the education, skill training, and support they need to make lifestyle modifications that enhance the likelihood of achieving optimal diabetes control. The scope and depth of information and skill training that patients with T1D need concerning nutrition are daunting at best, as Table 2 demonstrates. In addition, numerous studies have demonstrated that interventions such as MNT can help patients with T1D attain better diabetes control, although much more research is needed.[10,16–21]

There are many reasons for poor adherence to treatment recommendations for patient lifestyle education, including restrictions on reimbursement by medical insurance providers for MNT or diabetes self-management training (DSMT) sessions. There is also inadequate patient access to certified programs, especially outside of major urban areas. But, other

Table 2. Nutritional Information and Skills Needed for Optimal Diabetes Management in Patients with Type 1 Diabetes

Caloric and nutritional requirements
Daily servings of food groups
Carbohydrate, fat, and protein content of different foods
Effects of different macronutrients (carbohydrate, protein, and fat) on blood glucose
Understand portion size and how to estimate/calculate
Fiber content and effects on blood glucose
How to read food labels
Glycemic index and glycemic load of different foods
Meal planning
Meal preparation
Effects of changing timing/amount of food intake
Appropriate snacks
Food and drink to treat hypoglycemia

barriers also prevent healthcare and research institutions from making patient lifestyle intervention a priority in T1D treatment. As previously noted, attitudes regarding the role lifestyle factors play in T1D management, relative to their role in T2D or compared with the growing effort to develop CLC technology, contribute to the perception that diet and exercise are secondary concerns. There is also the notion (with some basis) that lifestyle modification can be frustratingly difficult to achieve, and this may decrease enthusiasm for referring patients to MNT or DSMT even if insurance reimbursement and good programs are available. Another common belief is the idea that only the most highly motivated patients are likely to benefit from lifestyle intervention, which, in turn, may lower the probability that those with the greatest need are referred.

At the other end of the spectrum, physicians and healthcare practitioners can overestimate lifestyle knowledge and skills in some T1D patients, especially those who follow intensive and highly sophisticated regimens, including use of diabetes technology. In fact, there is actually quite a bit of evidence[22–24] that T1D patients are not that highly skilled at tasks such as carbohydrate counting, which can have a negative effect on glucose control (although, not surprisingly, parents of children with T1D may be better at this task). Our focus group interviews with participants in AP trials at the University of Virginia Diabetes Technology Center found that only about one-third of patients say they are confident in their carbohydrate counting skills.[25] And, these individuals are typically highly engaged and invested in diabetes self-management, often utilizing the most sophisticated technologies available. If this ''elite'' patient population is having difficulty with basic lifestyle skills, what is the likely status for the more typical individual struggling to manage T1D? Restrictions in access and insurance coverage may not be the only, or even the most important, obstacle to reaching the goal of providing all patients with T1D adequate lifestyle education. Although it is easy (and valid) to complain about limitations in reimbursement and access, an interesting and potentially revealing statistic might be the number of annual MNT and DSMT sessions available to T1D patients that are not utilized.

Contemporary research and clinical practice in T1D are distinguished by two very different but co-existing ''realities.'' One reality is characterized by technological advances presently on the verge of producing CLC systems and other technologies with the capacity to transform T1D management. The other reality is characterized by the failure to provide patients with T1D with the most basic lifestyle education and skill training needed for optimal glucose control. The AP Initiative (and similar initiatives) has demonstrated the truly incredible accomplishments that are possible when scientific funding agencies, biotechnology industries, and diabetes advocacy organizations join forces to reach a goal. It seems at least a little ironic that the diabetes community will likely manage to build an AP system for outpatient use sooner than it can disseminate adequate lifestyle education and training to all people with T1D. Perhaps there will someday be a Patient Lifestyle Education and Modification Initiative.

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