The CATOD Approach: A Clinic for Athletes With Type One Diabetes

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Quality Improvement Success Stories are published by the American Diabetes Association in collaboration with the American College of Physicians and the National Diabetes Education Program. This series is intended to highlight best practices and strategies from programs and clinics that have successfully improved the quality of care for people with diabetes or related conditions. Each article in the series is reviewed and follows a standard format developed by the editors of *Clinical Diabetes*. The following article describes the establishment of a clinic for athletes with type 1 diabetes in Aarhus, Denmark.

Describe your practice setting and location.

The Clinic for Athletes With Type One Diabetes (CATOD) team is based at the Steno Diabetes Center Aarhus, Aarhus University Hospital, in Aarhus, Denmark.

Describe the specific quality gap addressed through the initiative.

The goal of the clinic is to help athletes with type 1 diabetes exercise at the same level as their healthy peers so they can compete and achieve high-rank positions in competitions. This is done by assisting them in improving their diabetes management skills in relation to physical training and competitions, which also supports their efforts to enhance their sporting performance. There has been a lack of existing mechanisms through which athletes with type 1 diabetes can network. Within this clinic, athletes with type 1 diabetes are brought together, allowing them to share peer support, tips, and tricks, which they have found very valuable.

How did you identify this quality gap? In other words, where did you get your baseline data?

We identified this gap in quality through our daily work with people with type 1 diabetes complaining about glucose excursions before, during, and after physical activity. We suspected that there was a lack of a clinical support that could assist people to exercise effectively despite having type 1 diabetes. Focus group interviews were collected with physically active individuals with type 1 diabetes to explore whether there was in fact an unmet demand for a clinic for athletes with type 1 diabetes.

Summarize the initial data for your practice (before the improvement initiative).

Outpatient clinics across Denmark were informed about the clinic through a formal Steno Diabetes Center network, and all diabetes clinics were encouraged to refer athletes with type 1 diabetes to the CATOD. Flyers encouraging other outpatient clinics to refer patients were distributed across the nation. Inclusion criteria were that the athletes should have a strong dedication to and passion for exercise, a desire to enhance their athletic performance, a goal of optimizing blood glucose regulation in relation to training and competition, and a commitment to sport as a central part of their daily routine.

Subject characteristics are presented in Supplementary Table S1. Out of 43 athletes, 41 successfully completed the program. Two athletes did not finish, one because of pregnancy and the other because of a bicycle accident.

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The average age of the athletes was 34 ± 13 years (range 15–70 years), and 31 (72%) were male. Of the athletes, 27 (63%) performed aerobic exercise (e.g., running, bicycling, and triathlon), six (14%) performed anaerobic exercise (e.g., weight lifting and CrossFit), and 10 (23%) performed mixed exercise (e.g., soccer, other ball games, and martial arts). The athletes generally competed at a regional or national level. The majority did not hold podium positions but had goals such as completing an Ironman triathlon or other endurance events. Only one world-class athlete participated. Twenty athletes used insulin pumps, and 23 used multiple daily injections of basal and bolus insulin.

To facilitate guidance on glycemic regulation during exercise, 12 athletes were provided with either flash glucose monitoring (FGM) or continuous glucose monitoring (CGM) devices, while 31 athletes already used a glucose-sensing system before they were referred to the clinic.

What was the time frame from initiation of your quality improvement (QI) initiative to its completion?

This report describes a proof-of-concept idea in clinical care and is based on the experiences and data from working with four groups of athletes included from May 2019 to December 2020. Each group of athletes participated in a 1-year program.

Describe your core QI team. Who served as project leader, and why was this person selected? Who else served on the team?

We recruited dedicated health care professionals from other clinics and hospitals with a genuine interest in physical exercise, diabetes, and metabolism and a dedication and desire to be part of a team of first-movers in the field. The CATOD team is composed of two diabetologists, a pediatrician, an exercise physiologist, a dietitian, and a nurse. A diabetologist is appointed as the team leader, but the hierarchy is flat, and every team member has a voice.

Describe the *structural* changes you made to your practice through this initiative.

One day per week, the CATOD team gathered to discuss the athletes' obstacles and improvements and to consult with the athletes, primarily through video consultations, which was the only strict structural change. Video consultations were necessary both because of the large geographic distances and also because of the coronavirus disease 2019 (COVID-19) lockdown occurring at the time the clinic was established. Therefore, proper working stations with multiple monitors, cameras, microphones, and secure and stable online meeting platforms were purchased to communicate with the athletes and assess and share data at the same time.

Describe the most important changes you made to your *process* of care delivery.

The CATOD program consisted of *1*) an initial 2-day diabetes camp, *2*) data collection and physical testing at the beginning and end of the program, and *3*) individual consultations.

During the camp, participants received education on various topics, including insulin, nutrition, sports nutrition, exercise physiology, carbohydrate and energy metabolism, and the complex interplay between diabetes and exercise, through a combination of lectures, interactive teaching sessions, and hands-on activities. Exercise management recommendations were based on the 2017 consensus statement on exercise for individuals with type 1 diabetes (1). In addition, designated opportunities were provided for athletes to network and share strategies among themselves, and the athletes were encouraged to join an athlete-driven Facebook group to support networking.

After the camp, the athletes attended an initial consultation in the outpatient clinic, where data about diabetes management and exercise level and accomplishments were assessed, and expectations regarding the program and goals related to exercise performance were collaboratively discussed and agreed upon. Data were recorded in the medical record and on a clinical record form.

After the initial consultation, the athletes engaged in in-person or video consultations every 2–4 weeks throughout the 1-year program. Consultations could be with one of the doctors, the exercise physiologist, the dietitian, the nurse, or a combination of team members, depending on individual athletes' needs, as the clinic took over diabetes care holistically during the program. During these consultations, glycemic control and performance during specific training sessions and competitions were reviewed, strategies were optimized, and overall good glycemic regulation was a goal. Athlete data were presented through *1*) different CGM, FGM, and insulin pump online platforms; *2*) sports watch tracking data; *3*) training diaries; and *4*) oral and written descriptions. The consultations followed the Plan-Do-Study-Act (PDSA) model (2) consistently working toward providing the athletes with individualized and

optimized diabetes management and performance strategies for different types of training. A graphical abstract of the program and a sample PDSA cycle for an athlete are provided in the Supplementary Material.

Data Collection

At baseline and at the end of the program, various assessments were conducted. These included physical performance tests according to athletes' sports disciplines and DEXA scan for body composition. In addition, data were collected on glycemic control, including the FGM- or CGM-derived metrics time in range, time below range, and time above range for the previous 14-day period, as well as A1C levels. A 3-day food intake record was also collected, from which energy and carbohydrate intake was calculated and evaluated by the dietitian. Patient-reported outcomes (PROs) were assessed using several standardized questionnaires, including the 12-item Short Form (SF-12) health survey, the World Health Organization-5 Well-Being Index (WHO-5), the Problem Areas in Diabetes (PAID) questionnaire, a short version of the Hypoglycemia Fear Survey (HFS-II-Short Form), and six statements about patients' involvement in their own treatment, rated on a 7-point Likert scale indicating the extent to which patients agreed with each. These statements related to their last outpatient visit and included: *1*) The treatment team asked for my own experiences on diabetes; *2*) I discussed questions and concerns with my treatment team; *3*) The treatment team encouraged me to ask questions or to discuss concerns; *4*) I was involved in decision-making; *5*) I was satisfactorily involved in discussions together with my treatment team on how I optimally take care of my disease; and *6*) I was satisfied with my last visit.

If you used the PDSA model, provide details for one example.

Athletes met with the clinic every 2–4 weeks, and the iterative PDSA model was used to change their care plan to make it the most effective for them. A sample is provided in the Supplementary Material.

Summarize your final outcome data (at the end of the improvement initiative) and how it compared with your baseline data.

Data from our clinic are presented in Supplementary Table S2. Given the pilot nature of this initiative, sample sizes were small and response rates for each component varied. Performance data, diabetes-related metrics, and PROs at baseline and completion were compared using paired Student *t* tests. A P value <0.05 was considered statistically significant.

Quality of life assessed by the WHO-5 and SF-12 (specifically assessing mental health) was observed to be relatively low at baseline and follow-up. After completing the program, the athletes reported a statistically significant improvement in their PAID score ($P = 0.005$), involvement in treatment statement agreement ($P = 0.01$), and HFS-II-Short Form scores for behavior ($P = 0.02$) and worry ($P = 0.01$). Their A1C levels were also significantly decreased ($P = 0.01$). Other diabetes-related metrics were not significantly improved, although small improvements were observed. Patients' VO_{2max} remained unchanged for the athletes performing aerobic exercise.

Because the questionnaires were completed anonymously, we could not assess differences between responders and nonresponders.

What are your next steps?

The CATOD program increased knowledge regarding type 1 diabetes and exercise among the clinicians who worked with the athletes, both through their observation of the athletes and through review of existing literature and studies. This increased knowledge and experience has now led to a wide range of new outreach activities from CATOD. These activities include beginners' courses, which are classes for people with type 1 diabetes who are not familiar with physical exercise, seminars for clinicians at a national level, webinars and road shows for people with type 1 diabetes, and written national and regional guidelines to spread knowledge regarding type 1 diabetes and exercise with the goal of increasing the number of children, adults, and athletes with type 1 diabetes who perform exercise successfully.

Our next steps are to offer virtual consultations for adults and children with type 1 diabetes who need expert advice regarding specific exercise obstacles. A two-consultation approach (one initial and one follow-up consultation, 30 minutes each) has already been tested in adults with promising results, indicating that this approach is more scalable than the athlete program.

By easing exercise barriers in type 1 diabetes and providing real-world, low-cost solutions, we seek to improve the long-term overall health of people with type 1 diabetes. The CATOD approach may inspire the development of similar programs to address the need of people with type 1 diabetes for more guidance regarding glycemic management during exercise and sports.

What lessons did you learn through your QI process that you would like to share with others?

First, this was a feasibility study, and we learned that the program was well received by participants, that outcomes trended toward the positive, and that the general consensus among athletes and the involved health care professionals was that the program should be continued and expanded. We also learned that individuals with type 1 diabetes struggle with exercise-related glycemic excursions, which influence their motivation and ability to engage in exercise, and that there is a huge unmet demand for practical guidance for individuals with type 1 diabetes who wish to be able to exercise unrestricted by diabetes.

Because of the low number of subjects and the clinical nature of our study, conclusions should not be overstated, but the data from the athletes completing the CATOD program point toward less diabetes distress, less fear of hypoglycemia, and increased involvement in treatment. Additionally, overall A1C levels were significantly improved and reached the target level for participants, without increasing the amount of time spent in hypoglycemia. Time in range was not significantly improved.

It is our belief that the CATOD program made a big difference for our athletes and was able to improve their diabetes management skills in relation to sports and daily life, and, perhaps more importantly, it had a positive impact on their psychological health.

This proof-of-concept report has some limitations that should be considered. The COVID-19 pandemic strongly affected our initiative, although we were able to continue with video consultations during lockdown. Many athletes were unable to attend regular training in their sport clubs, and almost all competitions were canceled during lockdown. Some of our athletes reported decreased motivation because of the lack of competitions, and many had to find alternative ways to exercise. This situation may have contributed to the lack of improvement in physical performance and also may have affected other outcome measures. Also, because this was a clinical initiative, we do not have complete datasets for all participants, and we did not have a control group, which makes it difficult to determine the causality of effects. Furthermore, 12 of the athletes received a glucose-sensing system at the beginning of the program, which also could have been a factor in the improvements found in A1C and PAID and HFS-II-Short Form scores (3).

The CATOD still continues its clinical work, now offering half-year programs for athletes, 12-week beginners' courses, consultations for adults and children seeking expert advice about exercise, and continuous outreach activities, including road shows, webinars, seminars, and educational materials about exercise and type 1 diabetes.

DUALITY OF INTEREST

No potential conflicts of interest relevant to this article were reported.

AUTHOR CONTRIBUTIONS

R.F.J., N.S., and E.T.V. wrote the manuscript and researched data. M.S., A.M., J.M., E.B., J.J.C., and E.T.V. conceptualized the clinical initiative. C.P. researched the PRO data. All authors reviewed and edited the manuscript. E.T.V. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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