Efficacy of Training in Obese Diabetic Patients

PER A. BJÖRNTORP, MD, PHD

The consensus of studies in non-insulin-dependent diabetes mellitus (NIDDM) seems to be that exercise has beneficial effects not only on glucose metabolism and insulin sensitivity, but also on elevated plasma lipids, blood pressure, and obesity frequently following NIDDM. Feasibility of effective physical training programs in subjects suffering from NIDDM seems, however, questionable on a large scale because NIDDM is found mainly in physically inactive subjects over the age of 50. In such individuals, cardiovascular complications may also prevent physical activity of sufficient intensity. Although direct information is limited, the possibility remains that regular exercise may prevent or postpone clinical NIDDM, particularly by preventing the development of obesity.

Exercise is traditionally an integral part of diabetes therapy. Historically, there are descriptions from antique cultures of the potential benefit of exercise in a condition that probably was diabetes, and exercise was used as therapy before the discovery of insulin.

DOES EXERCISE IMPROVE METABOLISM IN DIABETES MELLITUS? — Surprisingly, modern, controlled research on this fundamental question is fairly young. This area has been repeatedly reviewed (1), and a reasonable summary of these overviews indicates that exercise in insulin-dependent diabetes mellitus has to be used carefully, keeping in mind such potential complicating factors as risk for hypoglycemia and ketosis in situations of tight, poor glycemic control. On the other hand, there are seldom reasons to advise against normal physical activity or participation in sports in young diabetic patients.

The situation in non-insulin-dependent diabetes mellitus (NIDDM) is, however, seemingly less complicated. First, metabolic control is less fragile when exogenous insulin is not needed, and the complications of the ketotic situation are less prevalent. In addition, and more importantly, there are clearly several metabolic aberrations of NIDDM that benefit from exercise that will be focused on in this study.

Insulin sensitivity is enhanced by physical exercise. At least part of this effect is localized in muscle tissue, which becomes more sensitive to insulin. In addition, repeated contractions facilitate glucose transport in the absence of insulin (2). This effect has limited duration, and one has to consider exercise from a therapeutic point of view in the same way as diet and drug treatments—it has to be administered continuously. More specifically, because the duration of the effect of one exercise bout is a day or two, therapeutic exercise has to be recommended accordingly, with exercise performed about every second day.

It is likely that exercise has more long-lasting, "chronic" effects in the physically conditioned "trained" state. For example, physical training is followed by long-lasting adaptations of major tissues for insulin sensitivity. Muscle mass is enlarged, and there are morphological changes followed by increased insulin sensitivity. These include a higher abundance of red, type I insulin-sensitive muscle fibers and a higher density of capillaries (3). Such adaptations would be expected to have a longer duration than a few days. Furthermore, physical training is usually followed by a decrease of adipose tissue mass (4,5). Obesity is associated with insulin resistance, and when adipose tissue mass is diminished by physical training, insulin is consequently expected to be more effective. This, of course, is a particularly important feature in NIDDM that usually is combined with obesity. This effect of exercise on insulin sensitivity lasts longer than a few days.

In addition to obesity, NIDDM is frequently associated with other metabolic aberrations. Hyperlipidemia also is prevalent when diabetes is well controlled. Hypertension is often seen in combination with NIDDM. Exercise has been shown to be effective in improving the complicating factors associated with NIDDM (4).

Thus, it may seem evident that exercise is a valuable adjunct to the therapy of NIDDM and its complicating metabolic aberrations. There are, however, questions of feasibility of this kind of therapy that do not seem to have been sufficiently considered.

WHAT INTENSITY IS REQUIRED TO OBTAIN SIGNIFICANT EFFECTS? — Thus far, the studies performed have usually examined the effects of conventional exercise programs, comprising exercise sessions of moderate intensity and with a frequency of up to 2–3 times weekly. Another characteristic

FROM THE DEPARTMENT OF MEDICINE I, SAHLGREN'S HOSPITAL, UNIVERSITY OF GÖTEBORG, GÖTEBORG, SWEDEN.

ADDRESS CORRESPONDENCE AND REPRINT REQUESTS TO PER A. BJÖRNTORP, MD, PHD, DEPARTMENT OF MEDICINE I, SAHLGREN'S HOSPITAL, UNIVERSITY OF GÖTEBORG, S-413 45, GÖTEBORG, SWEDEN.

of these studies is the limited number of participants, probably caused by the difficulties in recruiting suitable patients. With these kinds of exercise programs, only limited effects have been seen on glucose homeostasis, and one may question the practical significance of such moderate changes. An exception here is a study with much higher intensity and frequency of the exercise sessions, where impressive improvements in glucose control, insulin sensitivity, and body fat contents were obtained (6).

This was a study of a minor group of participants ($n = 5$), and one might wonder if this was because of difficulties in recruiting suitable subjects for this rather demanding program. Thus, this study demonstrates that, with sufficient intensity and frequency, impressive metabolic improvements are possible to obtain with physical training.

IS PHYSICAL TRAINING FEASIBLE IN PATIENTS WITH NIDDM?

— These results question whether or not significant improvements of metabolism are possible to obtain with physical training in NIDDM. A recent study has dramatically questioned the feasibility and effectiveness of this kind of therapy (7). In a prospective population study of elderly men, those who developed NIDDM during a period of 10 yr were considered for a physical training program. However, only a limited number of these men were suitable for such a program because a large group had circulatory and other problems preventing participation in the training program. In addition, several men were not willing to participate. Most of this group dropped out for various reasons, including developing cardiovascular counter indications. Only two men completed the 1-yr program, and they were not improved metabolically.

This study then poses two important questions. First, whether there is a sufficient number of patients developing NIDDM whom it is possible to include in physical training programs. Second, whether such programs may be kept with sufficiently high intensity and frequency to be meaningful.

ARE PATIENTS DEVELOPING NIDDM POSSIBLE TO INCLUDE IN PHYSICAL TRAINING PROGRAMS?

— Who are the patients developing NIDDM? This is a disease that almost always develops in middle age or later. Incidence seems decisively higher between the fifth and sixth decades of age, and is apparently somewhat higher in Swedish men than women (8,9). Incidence figures are ~3% in studies on Swedish populations, in agreement with other analyses in urbanized, Western countries (10). Subjects who develop NIDDM are particularly physically inactive, as judged from measurements of oxygen uptake capacity (11). Thus, the therapist has the task of motivating sedentary middle-aged or older subjects to start exercising. In principle, this is a rather drastic change in life-style that, by many, will be considered as uncomfortable, even painful, and life-long. To be sufficiently effective, exercise habits will have to become a major priority. Most researchers and therapists dealing with physical exercise programs know that the drop-out frequency is considerable, mainly because of a combination of boredom and lack of time.

This factor has been analyzed in a quantitative way in a study composed of nonselected middle-aged men who suffered a myocardial infarction and who were selected at random in a physical training program (12). This program consisted of three weekly sessions supervised in a hospital. The men experienced considerable psychological benefit from the program that provided psychological reassurance and reinforced their physical capacity after damage to the central circulation. Nevertheless, after 3 yr, most of the training group dropped out. This study might give a particularly pessimistic view on keeping middle-aged men in long-term training programs, but it also illustrates one of the difficulties with physical training as a lifelong therapy in middle-aged subjects.

Two recent overviews (8,9) of the characteristics of men and women developing NIDDM also allow an analysis of the possibility of including patients with newly diagnosed NIDDM in programs of physical training. Circulatory complications are indeed frequent in such patients, including cardiovascular disease, myocardial infarction, and angina pectoris. Hypertension appears to be particularly abundant. Other major counterindications for exercise include locomotor and lung diseases. The size of the remaining group, without counterindications for physical training, is highly dependent on age. Younger subjects with NIDDM have less of these complications, whereas older subjects have more. Because NIDDM incidence increases sharply with age, these complications are prevalent when NIDDM has developed. NIDDM may actually comprise one facet of a metabolic syndrome, including hypertension, with a considerably elevated risk to develop cardiovascular disease and circulatory complications (13,14).

In summary, NIDDM most often develops in subjects at a rather advanced age, wherein the enthusiasm for a life-long physical exercise regime might be fairly limited, particularly because such subjects are unaccustomed to exercise. In addition, many of these subjects will have counterindications for exercise, particularly strenuous-type exercise, which is apparently required to obtain significant metabolic effects. With the small remaining group comes the difficulties of encouraging a life-long change of life-style, which many of them will consider uncomfortable.

HOW MANY NIDDM PATIENTS ARE TRAINABLE?

— Is the conclusion then that physical exercise as therapy for NIDDM is theoretically interesting, but practically not feasible? There are some points that need consideration. First, is it possible to estimate the number of NIDDM patients feasible for phys-

ical training programs? Before age 50 yr, NIDDM incidence is very low. Yet, the counterindications are probably less prevalent. There do not seem to be any hard figures on the prevalence of obesity in this group, but anecdotal evidence suggests that obesity is frequently found in fairly young subjects developing NIDDM. This is important because of the combined beneficial effects on obesity and NIDDM by physical training. Incidence figures in the group between 40 and 50 yr of age may be estimated at less than 1% of the population (8,9).

In the next decade, incidence may be ~2–3%. Estimates reveal that about half of this number will be impossible to train because of counterindications, and some of the remaining numbers might not be willing to participate. These problems will, of course, increase in the higher age groups (8,9).

The feasibility of physical training is highest in the youngest age groups and should be considered. The questions will then arise about the possibility of reaching sufficient intensity in such a group and whether nonintensive exercise (e.g., walking or golf) is effective? Unfortunately, there is very little data on these points. Furthermore, the psychological problems of motivation starting and remaining in a physical training program have attracted little attention. However, they appear to be an important area for further research, although epidemiological research suggests the benefits of low-intensity exercise, e.g., housework (15).

CAN PHYSICAL TRAINING PREVENT THE DEVELOPMENT OF NIDDM?— An important point to consider is whether or not exercise can prevent or postpone development of NIDDM. There is no good direct information available on the longitudinal studies of a population. Such studies would be exceedingly difficult to execute and would probably not allow conclusive results, because of the combination of the low incidence of NIDDM and the high age and low trainability of these subjects. Studies on rural populations, with drastic changes from high to low physical activity, show dramatic increases of NIDDM incidence (16). Applicability of these data to the reverse situation, increasing physical activity from low to high in western populations, is obviously associated with a number of difficulties, including differences in genetic background.

This is typically an area where sufficiently hard evidence to satisfy conventional research criteria will probably never be obtained (for reasons previously stated). Recommendations for intervention have to rest on insufficient and indirect evidence, as is often the case in clinical situations, or not issued at all. The potential dangers and inconveniences with such recommendations have to be considered. There is strong evidence that regular exercise counteracts established or developing obesity (4,5). There is also strong evidence that obesity increases the risk of developing NIDDM. The risk of continuous physical exercise, however, is very limited (17). Considering all the evidence, the resulting data recommend a more active life, with participation in different kinds of physical training activities throughout adulthood, middle-age, and the later years, all with the hope of postponing or preventing NIDDM. This is vital to individuals with genetic predisposition for the development of NIDDM and who are also obese.

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