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Effects of a community-based exercise and motivational intervention on physical fitness of subjects with type 2 diabetes

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Background: This study aimed to analyze the effects of a long-term community-based combined exercise program consisting of aerobic, resistance, flexibility and agility/balance training associated with motivational interviewing on physical fitness, physiological parameters and Physical Activity (PA) levels in middle-aged and older patients with Type 2 Diabetes (T2D). **Methods:** Sixty-nine diabetic subjects (mean age 63 ± 5.2 y, 62.3% M) underwent a 9-month exercise program and 12 motivational group meetings focused on PA, while 90 diabetic controls (mean age 64 ± 6.4 y, 58% M) underwent usual PA recommendations. Changes in physical fitness measured by Senior Fitness Tests, BMI, HbA1c, waist circumference (WC) and habitual PA expressed in Metabolic Equivalent of Tasks (METs)-min/week were evaluated in each group through the International PA Questionnaire and compared between groups. **Results:** At the end of the intervention participants showed significant improvements in BMI (29.3 to 27.6 kg/m^2, $P < 0.03$), HbA1c (6.5 to 6.1%, $P < 0.01$), WC (104.2 to 95.6 cm, $P < 0.01$) and all the physical fitness parameters ($P < 0.01$) but lower body flexibility ($P = 0.82$), while only upper body strength ($P = 0.04$) and agility ($P \leq 0.01$) improved significantly in controls. Habitual PA increased in participants and controls (+67 and +19 METs-min/week, respectively, $P \leq 0.01$). Changes in physical fitness and PA levels registered in the two groups differed significantly ($P < 0.01$), while improvements in BMI, HbA1c and WC did not ($P = 0.40$, $P = 0.52$, $P = 0.05$, respectively). **Conclusions:** A long-term motivational exercise-based intervention may be more effective than PA recommendations only in improving physical fitness and PA levels in individuals with T2D and produce similar health improvements.

Introduction

With a prevalence rate of 8.5% in adult population, diabetes is one of the most common chronic diseases worldwide.[1] In Italy, it affects 5.4% of the total population, but this number is thought to be underestimated.[2] Type 2 diabetes (T2D) is frequently associated with unhealthy diet and being overweight, inactive and having low levels of exercise tolerance and physical fitness.[3] Physical fitness has been defined as the physiological ability to perform daily life tasks safely and independently without undue fatigue; therefore, it encompasses several aspects, such as muscle strength, flexibility, walking speed, balance and agility.[4] All these attributes contribute to the functional status of the individual, and are useful in predicting disability, lack of independence, hospitalization, institutionalization, development of hypokinetic diseases and mortality in adult and old age.[5,6]

In people with T2D, poor physical fitness is associated with cardiovascular risk, cardiovascular mortality, mortality from all causes and with the risk of falls, particularly in the elderly. It also impacts the quality of life of these subjects.[7–9]

Regular Physical Activity (PA) has been associated not only with a reduced risk of developing chronic diseases but also with improvements in physical fitness resulting in enhanced functioning.[10,11] In order to improve disease management, current guidelines recommend that individuals with T2D undertake at least 150 min/week of moderate to vigorous aerobic exercise (e.g. walking) over a period of 3 days per week, with no more than two consecutive days between bouts of aerobic activity. In addition to aerobic training, individuals with T2D should undertake moderate to vigorous resistance exercises (e.g. push-up, squat, weight-lifting) at least 2–3 days/week. Flexibility training may be included but should not be undertaken in lieu of other recommended types of PA. Furthermore, individuals with T2D are encouraged to increase their total daily unstructured PA.[12] The physical fitness effects of adapted exercise programs including aerobic, resistance and flexibility training are widely recognized.[12–15]

However, the majority of individuals with T2D or at highest risk to develop the disease do not engage in regular PA.[16] Therefore, interventions aimed to increase PA and exercise levels in these individuals are needed.[17] Moreover, T2D patients should be guided to improve their lifestyle habits: initiatives that combine group or individual behavioral and motivational consultations with PA programs are more effective than single-component interventions using exercise paths alone in increasing PA levels and improving overall health in patients with T2D.[18–21]

This study aimed to analyze the effects of a long-term, community-based, exercise program consisting of aerobic, resistance, flexibility and agility/balance training combined with a group motivational interviewing intervention on PA levels, aerobic fitness, muscle strength, flexibility and agility/balance in middle-aged and older patients with T2D in the city of Naples, Italy.

Methods

This was a prospective study evaluating physical fitness and PA levels in a sample of individuals with T2D before and after a 9-month combined exercise and motivational intervention, compared with a control group of patients who did not participate in the intervention. The study was part of the community-based health promotion program funded by the National Center for Prevention and Control of Diseases of the Italian Ministry of Health.[22]

Participants and setting

Family physicians or diabeticians from two local doctors' associations who volunteered to participate in the investigation invited their patients to take part to the study. Patients were eligible if they were aged between 50–70 years, community-dwelling, received a diagnosis of T2D at least 1 year prior and were aware of their condition, and did not present major complications, limitations for PA and concomitant participation in supervised exercise programs. All participants were informed about the purpose of the study and the use of resulting data and signed an informed consent. Physicians discussed with all of them the benefits deriving from PA and exercise and invited them to increase their daily PA levels. Subjects who gave their consent were allocated in the study groups on a voluntary basis: those who decided to take part in the exercise program constituted the participants' group (group P); those who were not inclined to follow the exercise path were included in the control group (group C). The *a priori* power analysis, carried out considering an expected improvement of physical fitness in 60% of participants and a power of 0.80, suggested a total sample size of at least 28 individuals per group: therefore, we considered a number of 60 recruited persons as the minimum required to perform the study.

Interventions

Participants underwent a medical evaluation to certify their suitability for moderate and vigorous PA and were included in the motivational intervention. The exercise program consisted of 1-hour sessions performed two-to-three times per week on non-consecutive days over 9 months. Sessions were supervised by exercise professionals with expertise in adapted PA, and no more than 10 participants took part in each session. The exercise protocol was structured on the basis of the international recommendations.[17] Briefly, sessions consisted of five phases: warm-up (5 min) including continuous walking or marching; aerobic training (20 min) consisting of moderate and high-intensity brisk and interval walking, also with the employ of external load, obstacles and stairs circuits, at a Borg's scale level ranging from 12 to 17 points; circuit resistance exercises (20 min) repeated 20 (bilateral) or 30 times (unilateral) to enhance strength of lower limbs, upper limbs and torso with isotonic machines, barbells or floor exercises; agility/balance exercises (10 min) based on conditioned team games with balls or other equipment; flexibility static and dynamic exercises repeated 10 times (5 min).[17,23]

Twelve group meetings were offered to the group P subjects throughout the intervention with an interval of at least 2 weeks between sessions. Each meeting was guided by a psychologist with expertise on motivational interviewing for behavior change and trained in PA promotion. The meetings took 60 min each and included a discussion of PA benefits and risks, the PA recommendations for patients with T2D and the presentation of home-based and outdoor training methods, together with the analysis of barriers and problem solving. According to the theory of planned behavior and the health belief model, the psychologist sought to modify beliefs and attitudes about PA in participants considering those elements that promote behavior change, namely individual's attitudes, perceived social norms, intention to perform the behavior and perceived control over the change process.[24,25]

Both exercise and motivational sessions were carried out in selected gyms offering adequate spaces and trained staff.

The control group (group C) received care as usual, except for the measurements included in the study.

Outcomes

Fitness parameters. In order to evaluate possible variations in functional fitness, the following variables were assessed before (T_0) and at the end (T_1) of the intervention in participants and controls: aerobic fitness, important for walking distances and stair climbing; muscle strength, fundamental for performing household and other activities, such as walking, climbing stairs, carrying things and reducing the chance of falls; agility/dynamic balance, important in tasks requiring quick maneuvering, such as going to the bathroom or answering the phone and flexibility, important in tasks such as combing one's hair and reaching for a seat belt, for good posture, normal gait patterns and various mobility tasks. The battery of Senior Fitness Tests was used to assess the functional fitness domains.[25,26] The 2-min step in place test (SPT), which assesses the number of full steps completed in 2 min, was employed to evaluate aerobic endurance. The arm curl test (ACT) and chair stand test (CST) were used to evaluate upper and lower body strength; they consisted in assessing the number of bicep curls that could be completed in 30 s while holding a hand weight and of full stands that could be completed in 30 s, respectively. The back scratch test (BST) and chair sit-and-reach test (SRT) were used to assess upper and lower body flexibility, by measuring, respectively, the distance between one hand reaching over the shoulder and one up the middle of the back and that between hand and tip of toe from a sitting position at the front of chair, with legs extended and hands reaching toward the toes. The 8-foot up-and-go test (UGT), which measures the time required to get up from a seated position, walk 2.44 m, turn and return to seated position, was employed to evaluate agility. Results were expressed as a total count of repetitions (ACT, CST, SPT), distance/length in centimeters (BST, SRT), or time in seconds (UGT). Measures were collected in the same locations, by the same professionals and with the same methodologies.

Physiological parameters. Variations in BMI were investigated by measuring height and weight at T_0 and T_1 in participants and controls. Physicians provided also HbA1c and waist circumference (WC) values measured in all the enrolled patients at the start and at the end of the study.

Behavioural parameters. Habitual PA was evaluated in both groups through the short format of the International Physical Activity Questionnaire (IPAQ). This questionnaire allows to assess the total energy expenditure per week by considering the multiples of the resting metabolic rate (Metabolic Equivalent of Tasks, METs) resulting from minutes spent on vigorous (usually requiring 8 METs) and moderate intensity (4 METs) activities and walking (3.3 METs).[27] A total score lower than 600 MET-minutes/week indicates inactivity.

Acceptance. Subjects who participated in the motivational and exercise path were also interviewed about their satisfaction: a brief self-administered questionnaire was used to gather their level of appreciation toward organizational, relational, content and communication features of the program. Participants were asked to indicate if their acceptance regarding each of this aspect was none, low, uncertain, moderate, or high.

Statistical analyses

Demographic data were expressed as number and percentages of respondents per category, or mean values and ranges for age; comparisons were made through χ^2 test and Student's independent t test for age. Results from physical fitness tests, BMI, HbA1c levels, WC and habitual PA were expressed as mean values ± standard deviation (SD). Student's t test for paired samples was applied to compare physical fitness between T_0 and T_1 and habitual PA for each group, while differences between groups at each time were analyzed through Student's t test for independent samples. A repeated measure Analysis of Covariance (ANCOVA) was carried out to compare changes obtained in the two groups, adjusting for age, sex, height and weight. A p values of 0.05 was assumed as a significance level. Data were analyzed with IBM SPSS version 23 for Windows (SPSS, Chicago, IL, USA).

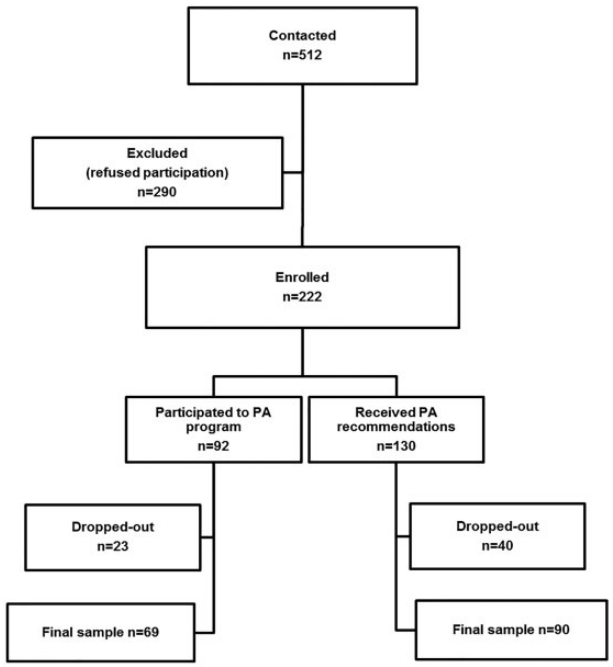

Figure 1 Flowchart for enrollment, assignment, interventions and drop-out of study participants

Results

A total of 512 eligible patients were contacted by physicians among their patients; on a total of 222 patients recruited, 69 participants who completed the exercise program (adherence rate 75%, mean age 63 ± 5.2 y, 62.3% M) and 90 controls who participated in the follow-up (adherence rate 69%, mean age 64 ± 6.4 y, 57.7% M) were included in the final analysis (figure 1). These sample sizes gave a statistical power value higher than 80% (alpha = 0.05) for all the outcomes considered. Demographic differences between the two groups were not significant (table 1). No adverse events were reported.

Table 2 shows mean values of the outcomes registered in both groups at T_0 and T_1 with correspondent variations and p values.

Fitness parameters. t test showed significant improvements ($P < 0.01$) related to all the physical fitness tests but SRT ($P = 0.82$) in group P, while only ACT ($P = 0.04$) and UGT ($P < 0.01$) results improved significantly between T_0 and T_1 in group C. ANCOVA results showed significant differences in physical fitness between the two groups ($P < 0.01$).

Physiological parameters. BMI ($P = 0.03$), HbA1c ($P < 0.01$) and WC ($P < 0.01$) values decreased significantly between the two times among participants, while only BMI reduction was significant in the control group ($P = 0.3$). However, ANCOVA did not show significant differences between the two groups regarding these three parameters ($P \geq 0.05$).

Behavioural parameters. The levels of habitual PA increased significantly in both groups at the end of the intervention ($P \leq 0.01$); ANCOVA results confirmed the more consistent increase registered in group P.

Acceptance. A high number of subjects from group P reported a moderate/high level of appreciation toward the different features of the intervention (figure 2).

Table 1 Baseline demographic characteristics of participant and control groups with corresponding *P* values

	Participants *N* = 69	Controls *N* = 90	*P*
Gender (%)	43 M (62.3)	52 M (57.7)	0.56[b]
Age ± SD (range)	63 ± 5.22 (59–70)	64 ± 6.48 (57–71)	0.28[a]
Educational level (%)			
Primary/middle school	8 (11.6)	10 (11.1)	0.99[b]
High school	52 (75.4)	68 (75.5)	
University degree	9 (13)	12 (13.3)	
Occupational condition (%)			
Unemployed/retired	60 (38)	71 (36)	0.18[b]
Employed	9 (50)	19 (54)	

a, independent t test; b, χ^2 test.

Discussion

Physical fitness is a fundamental aspect of health and quality of life for patients with T2D and it seems to be related to cardiovascular risk in this population, also independently by weight loss.[27] Exercise programs combining aerobic, resistance and flexibility training have shown to be effective in enhancing physical fitness of patients with T2D.[13–15,29]

The main findings of this study are that a 9-month community-based combined exercise program including aerobic, resistance, flexibility and also agility/balance training improves BMI, physical fitness and habitual PA levels in middle-aged and older subjects with T2D compared to control diabetic subjects undergoing an educational intervention.

Agility/balance exercises, which are commonly recommended for elderly people to reduce their risk of falls, are also useful for individuals with T2D, who are more pre-disposed to falls than non-diabetic individuals.[9] The studies which included this type of training in combined exercise programs for subjects with T2D, showed agility improvements in this population, reducing fall risk.[17,30]

In the present study, we compared the results of a combined exercise program with those deriving from an exclusively educational intervention. Although they were not created randomly but on a voluntary basis, the two samples came from the same population and were similar in age and sex. As for the other parameters, significant differences between the two groups were detected at the start of the intervention only in terms of CST and UGT performance, representing lower body strength and agility; however, differences recorded at the end of the study were greater and testify the role of supervised exercise and motivation.

The combined exercise program was effective in improving all the physical fitness components except lower body flexibility, as shown by SRT performance, which did not significantly variate in both groups. Probably, the type or the amount of flexibility exercises included in the protocol was not sufficient to increase lower body flexibility in people treated in the time interval considered. Although the aspect of whether flexibility training reduces risk of ulceration or injury in T2D was not directly evaluated, it was proven that it can enhance the ability of joints to move through their full range of motion and may be fundamental in older individuals with T2D who are at a high risk of falls.[12] However, it should be noted that also for SRT, ANCOVA detected a significant difference between groups. This represents an important issue that needs to be addressed in future interventions.

The educational intervention provided by physicians at the start of the study yielded positive results, as shown by the anthropometric and clinical measures and physical fitness performance of the control group, which generally improved between the two time periods considered; in particular, ANCOVA did not show significant differences related to the intervention regarding BMI, HbA1c and WC, even if their values were better in participants than in control at the end of the program. Furthermore, controls showed significantly increased levels of habitual PA at the end of the study. However, the integration of supervised exercise and motivational sessions led to better outcomes in terms of physical fitness, confirming the positive clinical effects of a similarly structured intervention.[19,28,29] Relationships with professionals and their communication skills, as

Table 2 BMI mean values, physical fitness tests performances and habitual PA measured at T_0 and T_1 in participant and control groups, with corresponding variations and *P* values

OUTCOMES VARIATIONS		T_0 *P* (independent *t* test)	T_1	Δ	*P* (paired *t* test)	*F*(1, 89)	*P* (ANCOVA)
SPT reps	**P**	87.4 ± 20.9	109.2 ± 27.3	21.8	<0.01	146.0	<0.01
	C	84.2 ± 18.2	90 ± 32.1	5.8	0.13		
		0.30	<0.01				
ACT reps	**P**	16.4 ± 3.2	24.1 ± 5.7	7.7	<0.01	75.8	<0.01
	C	17.2 ± 5.1	18.5 ± 3.4	1.3	0.04		
		0.22	<0.01				
CST reps	**P**	14.9 ± 3.3	19.7 ± 5.6	4.8	<0.01	4772.6	<0.01
	C	13.8 ± 2.8	14.7 ± 3.4	0.9	0.05		
		0.02	<0.01				
BST cm	**P**	−17.5 ± 15.4	−9.9 ± 11.3	7.6	<0.01	5259.8	<0.01
	C	−18.9 ± 12.3	−17.5 ± 10	1.4	0.40		
		0.53	<0.01				
SRT cm	**P**	−2.6 ± 4.9	−2.8 ± 5.8	−0.2	0.82	3.5	<0.01
	C	−3.1 ± 3.6	−2.9 ± 4.8	0.2	0.75		
		0.47	0.90				
UGT sec	**P**	5.6 ± 0.9	4.6 ± 0.7	1	<0.01	25.3	<0.01
	C	6 ± 1.1	5.2 ± 0.8	0.8	<0.01		
		0.01	<0.01				
BMI Kg/m^2	**P**	29.3 ± 5.4	27.6 ± 3.9	−1.7	0.03	4.1	0.40
	C	30.3 ± 4.9	28.7 ± 5.1	−1.6	0.03		
		0.22	0.13				
HbA1c %	**P**	6.5 ± 0.8	6.1 ± 0.7	−0.4	<0.01	0.5	0.52
	C	6.3 ± 0.9	6.2 ± 1	−0.1	0.48		
		0.14	0.46				
WC cm	**P**	104.2 ± 12.1	95.6 ± 14.7	−8.6	<0.01	3.7	0.05
	C	103.6 ± 13.6	99.8 ± 15.6	−3.8	0.08		
		0.77	0.08				
Habitual PA MET-min/week	**P**	728 ± 32.5	795 ± 37.2	67	<0.01	51.6	<0.01
	C	733 ± 44.8	752 ± 54.2	19	0.01		
		0.41	<0.01				

P, participants; C, controls; Δ, difference between times and groups; reps, total count of repetitions; SPT, 2-min step in place test; ACT, arm curl test; CST, chair stand test; BST, back scratch test; SRT, chair sit-and-reach test; UGT, 8-foot up-and-go test; BMI, Body Mass Index; WC, Waist Circumference.

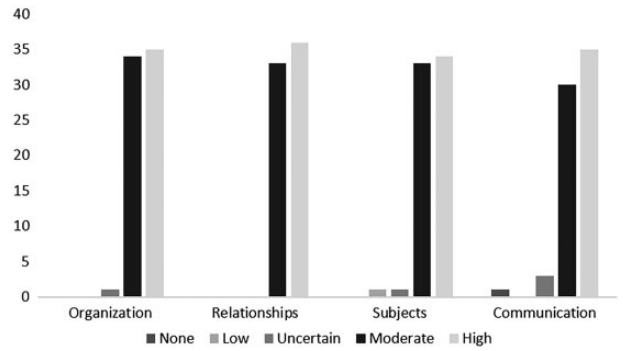

Figure 2 Number of participants to the intervention who expressed their level of satisfaction toward organization, relationships, subjects and communication features of the motivational and exercise program

well as organization and contents of motivational and exercise sessions were generally appreciated by participants.

The main limitation of this study is the lack of patients' randomization: it would be expected that subjects who were not willing to participate in the motivational, exercise-based program and constituted the group control were less motivated to improve their fitness and consequently showed minor changes than participants to the intervention. However, the two groups did not differ significantly neither in demographic features nor in baseline physical conditions and habitual PA levels. Moreover, the increase of habitual PA and the improvements of physical fitness reported by controls suggest that the effect of this possible bias was minimal.

Another important limitation is linked to patients' participation. In particular, low adherence to the study reflects low acceptance of similar healthy lifestyle promotion interventions in the population considered, which is usually composed of sedentary people. In fact, in Italy the 42% of individuals aged 55–59 years, 42.3% of those aged 60–64 years and 47.5% of those aged 65–74 years do not practice PA, with higher levels of inactivity in southern regions.[2] However, the highest rate of employed persons found among non-responders suggests that a great number of persons with T2D do not comply with PA recommendations due to the difficulties in combining work and exercise.

Furthermore, a considerable number of dropouts was observed among participants. Even though we did not investigate in depth the reasons of this, we observed that some gyms showed higher dropout rates than the others (data not shown). This could be tied to the kind of support patients received from the staff of these facilities and should be considered in future interventions. However, dropout levels registered in this study are comparable to those reported by similar studies.[17,30,31]

Finally, it should be noted that our intervention involved only individuals aged 50–70 years, while in Italy the highest age class affected by T2D is that of older adults aged ≥75 y (prevalence rate 19.8%).[2]

In conclusion, a long-term community-based intervention including a motivational path and a supervised exercise program may improve physical fitness and increase PA levels in individuals with T2D. It could have positive consequences on cardiovascular risk, fall risk and quality of life in these subjects, representing a cost-saving strategy for the management of the disease.[32,33]

The structured intervention turned out to be feasible in the Neapolitan community: it was appreciated by participants and did

not require great amounts of resources; in the perspective of its application by the Italian National Health System, the duration of similar programs could be reduced to increase their sustainability. A follow-up should be performed to evaluate the durability of the results obtained.

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Conflicts of interest: None declared.

Key points

- A motivational program may increase compliance to PA in people with T2Ds.
- Structured exercise is useful to improve physical fitness in diabetic adults.
- An integrated exercise-based motivational intervention may represent an effective public health strategy to enhance self-management of the disease in T2Ds.

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