Physical Training in a Medical Fitness Room for Patients with Chronic Diseases: Functional and Metabolic Outcomes

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ABSTRACT: **Background:** Physical inactivity is a pivotal factor in the development and progression of various chronic diseases. However, most fitness facilities exclude unhealthy individuals. Therefore, an exercise program that admits such patients is imperative.

Objectives: To evaluate the effectiveness of a fitness facility that admits adult subjects with multiple chronic diseases.

Methods: We conducted a retrospective screening of patient records from the Medical Fitness Facility at Meir Medical Center, Israel. Intake of subjects was done by a multidisciplinary team. For each individual, personalized diet and exercise plans were developed and patients attended the facility twice a week. Each participant was evaluated at enrolment and after 4 months for well-being, metabolic parameters, exercise capacity, and laboratory blood tests.

Results: A total of 838 individuals were enrolled, mean age 57 years. Their medical conditions included dyslipidemia (48.8%), hypertension (37.6%), and diabetes mellitus (24.9%), followed by musculoskeletal problems (arthropathy 19%, lower back pain 16.1%) and ischemic heart disease (13.4%). Less common diagnoses were vascular diseases, pulmonary diseases, and malignancy. Only 40.5% of participants adhered to the regimen with advanced age being the best predictor for adherence. At the follow-up visit, body mass index was lower (31.2 vs. 30.2 kg/m^2, $P < 0.0001$), exercise capacity increased (measured as maximal MET; 7.1 vs. 8.1, $P < 0.0001$), and well-being improved (measured by Short Form Survey [SF-36]; 69.3 vs. 76.0, $P < 0.0001$).

Conclusions: We show that a fitness program for patients with multiple chronic diseases is feasible and effective in improving prognostic parameters, albeit significantly challenged by adherence limitations.

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KEY WORDS: physical fitness, chronic diseases, metabolic equivalents, body mass index (BMI), waist circumference

For editorial see page 51

Decreased physical activity poses a serious health problem for patients with chronic diseases, leading to increased morbidity and mortality. The importance of regular exercise has been unequivocally established both in healthy [1] and ill subjects. In its Global Recommendations on Physical Activity, the World Health Organization defined inactivity as the fourth leading risk factor for global mortality, and outlined recommendations for physical activity according to age [2]. These guidelines, however, do not apply to specific populations, such as patients with limited mobility. The recommendations also advise extra precautions in others, such as postpartum women and cardiac patients.

Ample data are available on the role of physical inactivity in the development of a wide range of chronic, non-communicable diseases [3]. Metabolic abnormalities and other cardiovascular risk factors are best managed when regular exercise is incorporated into the treatment regimen. Strong evidence indicates that this statement applies to diabetes mellitus [4], hyperlipidemia [5], hypertension [6], and obesity [7].

Regular exercise has been shown to be beneficial for organ systems that are affected by chronic disease, particularly the heart and lungs, prompting specialized rehabilitation programs. For example, inactivity in chronic obstructive pulmonary disease patients independently predicts poor outcomes across several aspects of the disease [8].

Another category of chronic disorders associated with reduced physical activity includes entities that involve pain. Limited use of a painful limb may result in loss of joint motion, contracture, and muscle atrophy, thereby exacerbating the damage caused by the underlying disease. Therefore, exercise therapy is recommended in diseases such as rheumatoid arthritis [9] and lower back pain [10].

Patients with various chronic diseases share similar difficulties in achieving adequate physical activity. A major hurdle is the inaccessibility of fitness rooms in which an individual can engage in long-term, professionally supervised physical training. Accordingly, the Israeli Law for Fitness Facilities requires a signed form stating that the member is healthy or has a medical condition that does not expose that individual to risk while exercising [11].

In this article, we report the outcomes of patients who exercised in a medical fitness room uniquely designed to admit any individual with chronic diseases. Patients with various types of medical problems were encouraged to become members. Intake was performed by a multidisciplinary team that devised individualized training programs for each subject and monitored progress.

PATIENTS AND METHODS

STUDY DESIGN AND POPULATION

This retrospective study is based on patient records from the Medical Fitness Facility at Meir Medical Center. Data were collected from July 2014 through April 2015. Participants with chronic medical problems were referred to the facility by treating physicians or by self-referral. No specific exclusion criteria were implemented. Each participant was evaluated by the facility team, which included a physician, physiologist, clinical dietitian, physiotherapist, fitness instructor, and psychologist. Personalized diet and exercise plans were developed at the first visit, and the patients attended the facility twice a week thereafter for 90 minute sessions. Target pulse was determined by clinical assessment taking into account patient cardiovascular and musculoskeletal status as well as medications taken.

The training regimen included:

1. Warm-up and flexibility exercises
2. Cardiovascular activity using three different machines
3. Isometric exercise using six different pneumatic fitness machines for the following muscle groups: shoulders and back, pectorals, abdominal, upper and lower limbs

Patients were instructed to perform two sets of 15 repetitions each, with gradual increase of exertion intensity. Each participant was reevaluated by the team after 4 months. The study was approved by the Meir Medical Center review board (application number 0158-14-MMC).

MEASURED VARIABLES

Participants were evaluated at baseline and at follow-up visits every 4 months for:

- Physical and mental health using the patient-reported short-form (SF)-36 questionnaire [12]
- Physiologic indices, including body mass index (BMI), waist circumference, and resting metabolic rate, as well as percentages of muscle mass, fat, and visceral fat measured by electrical impedance (Karada Scan, Omron, the Netherlands)
- Treadmill stress test (Bruce protocol [13]), with exercise capacity expressed as maximal metabolic equivalent (MET) achieved
- Laboratory blood test results

DATA ANALYSIS

Data are presented as mean and range or standard deviation for continuous variables and as numbers and percentage for nominal parameters.

Continuous data were tested for normality (Shapiro–Wilk test) and differences were conducted using *t*-test or Mann–Whitney non-parametric test, each when appropriate. Changes between baseline to follow-up were analyzed with paired *t*-test or Wilcoxon non-parametric test. Multivariable analysis was conducted with logistic regression to find independent variables that explain adherence to physical activity. Significant statistical difference was defined as $P < 0.05$. Statistical analysis was performed using IBM SPSS statistics software, version 23 (IBM Corp, Armonk, NY, USA)

RESULTS

BASELINE CHARACTERISTICS OF ENROLLED MEMBERS

A total of 838 individuals with a mean age of 57.0 years (range 16.6–88.0) were included in the study [Table 1]. These indi-

Table 1. Baseline characteristics of enrolled members

Total population, n	838		
Mean age (years), (SD, range)	57.0 (± 14.7, 16.6–88.0)		
	%		**n**
Female	53.8		451
Co-morbidities			
Metabolic			
Dyslipidemia	48.8		409
Hypertension	37.6		315
Diabetes mellitus	24.9		209
Musculoskeletal			
Arthropathy	19.0		159
Lower back pain	16.1		135
Cardiovascular			
Ischemic heart disease	13.4		112
Cerebrovascular disease	1.9		16
Peripheral vascular disease	0.5		4
Pulmonary disease	6.0		50
Malignancy	2.0		17
Physical and functional status	**Mean**	**SD (range)**	**n**
BMI (kg/m²)	32.2	6.5 (18.1–57.0)	703
Fat (%)	38.3	10.7 (5.0–59.3)	688
Muscle (%)	27.0	5.3 (10.0–57.1)	685
Visceral fat (%)	13.4	5.2 (1.0–30.0)	680
Waist circumference (cm)	106.3	15.5 (65.0–196.0)	679
Systolic blood pressure (mmHg)	124.1	11.2 (80–180)	714
Diastolic blood pressure (mmHg)	73.2	6.6 (50–105)	714
Maximum MET (kcal/kg/hr)	7.1	2.2 (1.4–14.1)	710
SF-36	68.7	18.9 (9.38–9.48)	620
Metabolic status			
Glucose (mg/dl)	108.3	32.4 (46–334)	507
Hemoglobin A1C (%)	6.7	1.3 (4.7–12.9)	205
HDL (mg/dl)	48.0	14.4 (24–146)	483
LDL (mg/dl)	104.2	31.5 (32.5–204.5)	456
Triglycerides (mg/dl)	149.8	83.6 (41–134)	488

BMI = body mass index, SF-36 = Short Form Survey, HDL = high-density lipoproteins, LDL = low-density lipoproteins, SD = standard deviation, MET = maximal metabolic equivalent viduals were not eligible to sign a bona fide health declaration required by standard fitness facilities. The most prevalent chronic medical diagnoses in enrolled individuals were dyslipidemia (48.8%), hypertension (37.6%), and diabetes mellitus (24.9%). The second most common problem was musculoskeletal, including arthropathy (19%) and lower back pain (16.1%). Next were ischemic heart diseases (13.4%), pulmonary abnormalities (6%), malignancy (2%), cerebrovascular disease (1.9%), and peripheral vascular disease (0.5%).

In terms of physical parameters, the average BMI was 32.2 kg/m^2, well within the obesity range. This finding corresponds to increased fat percentage (38.3%) and waist circumference (106.3 cm) along with low percentage of muscle mass (27%). Accordingly, a low level of fitness was reflected by an average maximal MET of 7.1 kcal/kg/hr.

Intriguingly, despite the reported metabolic abnormalities, the values of high-density lipoproteins (HDL) (48 mg/dl), triglycerides (149.8 mg/dl), and blood pressure (124/73 mmHg) were fairly well-controlled. Among participants with diabetes mellitus, mean glucose (108 mg/dl) and hemoglobin A1C (6.7%) were slightly increased. Mean low-density lipoproteins (LDL) (104 mg/dl) was also slightly above the target values for this population.

Table 2. Comparison between adherent and non-adherent subjects

Variable	Adherent		Non-adherent		*P* value
	n	% of baseline	n	% of baseline	
Total	339	40. 5	499	59.6	
		% of adherent		**% of non-adherent**	
Female	153	45.1	298	59.7	< 0.0001
Married	234	69.0	231	46.3	< 0.0001
Employed	158	46.6	201	40.3	NS
Self-referred	129	38.1	209	41.9	NS
Co-morbidities					
Metabolic					
Dyslipidemia	211	62.2	228	45.7	0.0003
Hypertension	160	47.2	190	38.1	NS
Diabetes mellitus	96	28.3	135	27.1	NS
Musculoskeletal	107	31.6	142	28.5	NS
Cardiovascular	75	22.1	53	10.6	0.0009
Pulmonary	36	10.6	16	3.2	0.0001
Malignancy	8	2.4	19	3.8	NS
	n	**Mean ± SD**	**n**	**Mean ± SD**	
Age (years)	328	60.8 ± 12.5	479	54.4 ± 15.5	0.0002
SF-36	287	71.7 ± 18.0	333	66.1 ± 19.3	0.0002
BMI (kg/m^2)	328	31.5 ± 6.0	375	32.9 ± 6.8	0.0037
Fat (%)	323	36.6 ± 10.9	366	39.8 ± 10.2	< 0.0001
Muscle (%)	321	27.7 ± 5.5	364	26.3 ± 4.9	< 0.0001
Visceral fat (%)	321	13.7 ± 5.4	359	13.1 ± 4.9	0.0005
Waist circumference (cm)	308	105.6 ± 14.2	371	106.9 ± 16.4	NS
Maximum MET (kcal/kg/hr)	332	7.1 ± 2.3	378	7.1 ± 2.1	NS

SF-36 = Short Form Survey, BMI = body mass index, MET = maximal metabolic equivalent, NS = not significant, SD = standard deviation

CHARACTERIZATION OF PARTICIPANTS WHO ADHERED TO FITNESS ROOM ACTIVITY

Only 40.5% of participants adhered to their physical activity regimen from enrollment to the first follow-up visit 4 months later [Table 2]. Univariate analysis showed that, compared to non-adherent individuals, the group that persisted included fewer females (45.1 vs. 59.7%, $P < 0.0001$), more married people (69 vs. 46.3%, $P < 0.0001$), and a larger proportion of participants with cardiovascular (22.1 vs. 10.6%, $P = 0.0009$) and pulmonary (10.6 vs. 3.2%, $P = 0.0001$) diseases. In addition, individuals who remained active were older than those who withdrew (60.8 vs. 54.4 yrs, $P = 0.0002$), with slightly better physical parameters upon enrollment, reflected by lower BMI (31.5 vs. 32.9 kg/m^2, $P = 0.0037$) and fat (36.6 vs. 39.8%, $P < 0.0001$). These findings correlate with a higher baseline Short Form Survey (SF-36) score (71.7 vs. 66.1; $P = 0.0002$). Nevertheless, multivariate analysis identified only advanced age and pulmonary disease as predictors of adherence in this group (not shown).

THE IMPACT OF ADHERENCE ON PHYSICAL, FUNCTIONAL, AND METABOLIC VARIABLES

We examined the effects of use of a medical fitness room on subjects who attended the first follow-up visit [Table 3]. The most notable effects of adherence to physical training were decreased BMI (31.5 vs. 30.2 kg/m^2, $P < 0.0001$), improved body composition including lower fat percentage (36.3 vs. 34.7%, $P < 0.0001$), and decreased waist circumference (105.6

Table 3. Changes in physical, functional, and metabolic indexes in adherent subjects from baseline to follow-up visit

Physical and functional status	Baseline		Follow-up		*P* value	n
	mean	SD	mean	SD		
BMI (kg/m^2)	31.5	6.0	30.2	5.4	< 0.0001	328
Fat (%)	36.3	11.0	34.7	11.1	< 0.0001	306
Muscle (%)	27.9	5.6	28.7	5.2	< 0.0001	305
Visceral fat (%)	13.7	5.4	14.0	18.0	NS	307
Waist circumference (cm)	105.6	13.7	101.8	12.5	< 0.0001	236
Systolic blood pressure (mmHg)	123.5	11.7	124.7	10.3	NS	332
Diastolic blood pressure (mmHg)	72.9	6.4	72.9	5.9	NS	332
Maximum MET (kcal/kg/hr)	7.1	2.3	8.1	2.5	< 0.0001	330
SF-36	69.3	17.7	76.0	16.0	< 0.0001	197
Metabolic values						
Glucose (mg/dl)	113.9	39.1	104.3	19.7	0.0137	46
Hemoglobin A1C %)	7.5	2.2	6.8	1.3	0.0336	15
HDL (mg/dl)	49.9	15.2	47.3	10.5	NS	43
LDL (mg/dl)	102.1	27.6	101.1	31.3	NS	41
Triglycerides (mg/dl)	158.3	74.0	135.7	58.4	0.0116	44

BMI = body mass index, SF-36 = Short Form Survey, HDL = high-density lipoproteins, LDL = low-density lipoproteins, MET = maximal metabolic equivalent, SD = standard deviation, NS = not significant vs. 101.8 cm, $P < 0.0001$), as well as increased muscle mass (27.9 vs. 28.7%, $P < 0.0001$). Functional performance was also enhanced, as expressed by maximal MET (7.1 vs. 8.1 kcal/kg/hr, $P < 0.0001$). These beneficial changes were associated with a considerable increase in well-being, as reported in SF-36 (69.3 vs. 76.0, $P < 0.0001$).

In terms of metabolic effects, the data imply that a decrease was achieved in fasting glucose (113.9 vs. 104.3 mg/dl; $P = 0.014$) and hemoglobin A1C (7.5 vs. 6.8%; $P = 0.034$). Likewise, triglyceride levels were considerably lowered (158.3 vs. 135.7 mg/dl; $P = 0.01$). It should be noted, however, that fewer metabolic values were obtained than physical and functional data.

DISCUSSION

It is unusual to refer to all individuals with chronic diseases as a population with common needs due to the diverse etiologies of their health problems, which may include metabolic, organ specific, and pain syndromes. These individuals are usually excluded from fitness facilities due to their medical conditions, and lack of physical activity is likely to exacerbate their chronic illness. Furthermore, rehabilitation programs and clinical trials usually implement selective inclusion criteria that do not favor individuals with complex, real-life co-morbidities. In the present study, we report the outcomes of individuals with various chronic diseases who engaged in physical activity in a medical fitness facility designed specifically for this purpose. The focus of this work was to present the medical fitness room as a versatile tool that is applicable to a heterogeneous population. Within the first 4 months of training, the participants obtained several beneficial changes, and those implications merit further discussion.

The study group started with a high average BMI of 31.5 kg/m^2, which decreased by 1.4 kg/m^2 following training. Obesity is associated with a significant increase in morbidity and mortality. With a BMI above 25 kg/m^2, mortality increases by 30% for every 5 kg/m^2 increment [14]. Sustained weight loss of as little as 3–5% is associated with a clinically meaningful decrease in cardiovascular risk factors [15], as well as decreased mortality [16]. The benefit of weight loss is even more pronounced in overweight and obese adults with chronic diseases. For example, in adults with type 2 diabetes, a 2% to 5% weight loss leads to decreased fasting plasma glucose and hemoglobin A1C. There is also a direct correlation between the amount of lost weight and improved lipid profile and blood pressure [15].

Most importantly, during the 4 month follow-up, the median exercise capacity increased by an average of 1 MET. MET is the accepted clinical measure of exercise capacity among men with and without cardiovascular disease. Peak exercise capacity, as measured in METs, was shown to be the strongest predictor of mortality during an average follow-up of 6.2 years [17]. An increase of 1 MET was associated with a 12% improvement in survival. Similarly, exercise capacity was an independent predictor of death in asymptomatic women, with mortality risk decreased by 17% for each 1 MET increment [18]. It should be stressed that MET (as well as muscle mass) is an outcome that cannot be changed by any means other than physical activity. The enhanced physical performance was experienced by the subjects as improved quality of life. This aspect was assessed by the SF-36, a patient-reported instrument used to measure physical and mental quality of life.

Interestingly, HDL, triglycerides, and blood pressure values at baseline were reasonably well-controlled despite chronic diseases such as diabetes mellitus, hypertension, and dyslipidemia. Mean glucose, hemoglobin A1C, and LDL were only slightly above normal levels. At follow-up, a statistically significant decrease was seen in fasting glucose and triglyceride levels. However, as information on prescription medications was not available, we cannot confirm that physical training allowed a better glycemic, hypertensive, and lipid profile control with fewer prescribed medications, as was suggested by previous reports.

The increasing prevalence of chronic conditions with age creates co-morbidities that constitute a significant barrier to physical activity, thus, leading to low rates (40.5%) of adherence. Previous studies showed comparable rates of adherence (approximately 50%) to prescribed physical activity at 3–6 months follow-up [19,20]. The adherence rate in these reports was significantly lower among patients who had been inactive at baseline. The major reasons for non-adherence among older individuals included compromised well-being and pain [21,22]. Among younger patients, economic factors and lack of time were more prominent explanations, and the type of occupation as well as pregnancy appear to play a role as well [23,24]. Higher adherence was associated with advanced age, home-based activities, and patients referred to physical activity due to diagnoses such as diabetes and high blood pressure. Accordingly, the current study also found older age as a predictor of adherence. Intriguingly, pulmonary disease was predictive as well in our study. This finding may be explained by the fact this subgroup of participants was closely observed by the referring pulmonology department, which provided an additional source of support. Nevertheless, our data do not indicate that physician referral is superior to self-referral in terms of patient adherence [Table 2]. In the present study, several measures were taken to confront the problem of low adherence. First, patients were referred to an interview with a psychologist whose purpose was to identify and resolve personal difficulties that may cause low adherence. Second, a personalized diet and exercise plan were developed for each participant based on their specific abilities and preferences. Third, an instructor was present at every exercise session, providing advice and encouragement in the course of exercise.

This study presents several caveats. The design of this work does not include long-term follow-up visits beyond a 4 month intervention, which limits our ability to assess the durability of the effects conferred by physical training on morbidity and mortality. Future studies are warranted to directly address this question. Furthermore, because of the low volume of metabolic data and the diversity of patient co-morbidities, conclusions regarding glycemic control and lipid profile should be drawn with caution. Due to non-adherence, the results of physical activity were evaluated in a minority of the enrolled individuals, as almost 60% of enrollees did not perform physical activity in the fitness room. Finally, the available database did not include adverse events related to subjects with chronic diseases who engaged in physical activity.

CONCLUSIONS

Although physical activity is a critical factor in improving the prognosis of individuals with chronic diseases, it is often overlooked or neglected. This report outlines the feasibility and benefits of participation in a specialized, multidisciplinary medical fitness room program designed for individuals with chronic diseases. The data presented show significant improvements in body weight, exercise capacity, and quality of life despite chronic morbidity. However, we also highlight the extent of non-adherence to physical activity in this population. Further research with long-term follow-up is needed to study estimated effects on morbidity and mortality.

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Capsule

Restraining intestinal lymphocyte migration

Migration of intraepithelial lymphocytes (IELs) is controlled by several factors. **Sumida** and colleagues reported that G protein-coupled receptor 55 (GPR55) negatively regulates IEL migration in the small intestine. Lysophosphatidylinositols, a class of ligands active on GPR55 in vitro, are abundant in the small intestine. In response to indomethacin-induced intestinal leakage, GPR55-deficient mice recruited greater numbers of IELs and were more resistant to intestinal injury.

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