Relationship Between Physical Activity and Physical Fitness in Obese, Insulin-Dependent Diabetics with Hypertension

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Abstract

Background: Several recent studies have reported significantly larger declines in relative physical fitness (PF) of patients with diabetes (DM) versus those without diabetes. In our study, we set out to establish that the presence of DM in obese patients with hypertension (HT) is linked to a significant decrease in physical activity (PA), and also to PF which is important for ensuring mobility, independence at an elderly age, and efficiency in everyday life. We also sought to demonstrate the protective role of PA and PF, and to show that more attention must be paid to the importance of both PA and PF in prevention and therapy of non-communicable diseases. The study assessed the relationships between the current level of PA and PA in childhood and the level of PF of obese people aged 40+ with co-existing HT.

Methods: The study included 82 obese patients with co-existing HT in their history. In order to assess the level of PA we used the International Physical Activity Questionnaire (IPAQ). PF was assessed by observing the performance of patients in seven selected tasks (Fitness Test): 30 Second Chair Stand, Handgrip Strength Test, Sit-and-Reach Test, One Leg Stand Test, Plank Test, Wall Squat Test, and 2-Minute Step-in-Place Test.

Results: There was a significant differentiation in the amount of MET-min./week obtained for particular activities (vigorous, moderate, walking) by men (p=0.048) with significant grater amount of vigorous activity than moderate activity (p=0.024). When subjects were classified according to their IPAQ questionnaire category, 24.4% were classified as having a high level of PA, 45.1% a sufficient level, and 30.5% an insufficient level of PA. We noted that the higher the level of PA, the higher the PF – even in obese participants with HT. On the other hand, co-existing diabetes lowers almost all analyzed parameters, both biochemical and fitness ones.

Conclusions: The analysed PF is probably not related directly to obesity of the participants or coexisting HT. On the other hand, the current PA level, the deficiency of which seems to be related to low PF and/or HT do seem to be related to the degree of PF.

Background

The Survey of Health, Ageing and Retirement in Europe (SHARE) has shown that 70.1% of the population aged 55–60 years suffers from one or more chronic diseases, while this percentage is higher than 80% for people aged 65+ [1]. The chronic diseases include conditions such as backache, osteoporosis, circulatory system diseases, obesity, type 2 diabetes and stress, for the prevention and/or therapy of which physical activity is recommended [2]. However, the awareness of risks related to insufficient physical activity (PA) is very low, which indicates that there is an urgent need for more effective health education and health promotion [3] and that this may be a worldwide problem. For example, in Canada a significant decrease in PA levels in the last several decades was associated with an increase of obesity and other related co-morbidities, such as hypertension (HT), heart failures, diabetes [4]. As the problem concerns over 20% of adult population in Canada together with obtaining new research evidence data guidelines and recommendations for HT education has been immediately up-dated. In Europe, Bennie, et al. [5] in their comparative study on PA and sedentary behaviours (using the IPAQ questionnaire) in adults from 32 European countries, report about 300 minutes average sitting time a week for the average European adult. Although, geographical and cultural factors differentiating European nations prevented the generalization of the scores, it is worth noting that high-sit/low-active individuals comprised 10% of the examined sample and these participants tended to self-report their general health state as “bad” or “very bad.” In Poland, according to MultiSport Index 2019 almost half of the Poles spend more than 5 hours a day in a sitting position and 16% sat for more than 9 hours per day [6].

The effects and benefits of PA on health have been widely described in the literature, both in the context of the prevention of non-communicable diseases (NCDs) and their therapy [7, 8]. Physical activity at various stages of life plays a valuable role, from ensuring mobility, enabling recreation and maintaining social interaction, to the possibility of maintaining everyday activity and independence at an elderly age. Regular exercise and PA normalise glycaemia and positively affect the lipid profile [9], body composition, the functions of blood vessels, lung function, immune system and cardiac output [10]. On the contrary, I-Min Lee et al. [11] indicated that physical inactivity (which was defined as insufficient PA) causes 6–10% of several major non-communicable diseases, including coronary heart disease, type 2 diabetes, and breast and colon cancers. With the elimination of physical inactivity, life expectancy of the world population might be expected to increase by 0.68 years [12]. Physical inactivity seems to have an effect similar to that of obesity as risk factor for poor health (0.5–0.7 years) [12].

It is known that PA habits are important predictors of weight history. Longer-term habitual PA in adolescents, particularly at higher intensity, has been shown to minimise weight gain in adulthood, in both men and women, but particularly in women [13], and also to lower the odds of incident hypertension, especially in women with moderate to high levels of cardiorespiratory fitness [14]. A study by Lee et al. [15] found that when considered simultaneously fitness attenuated, but did not eliminate, the risks of impaired fasting glucose and type 2 diabetes when associated with obesity, the highest risk was found in obese and unfit men. In the study by Chase et al. [16] individuals with previously known diabetes (DM) had the lowest fitness in the fully adjusted model. It was observed that the functional fitness decreases gradually with an increased impairment in glucose regulation. Both patients with newly diagnosed DM and the ones with impaired glucose tolerance had significantly poorer physical performance compared to those with normal glycaemia. Michaliszyn et al. [17] indicated that greater fitness levels predicted better glycaemic control even among adolescents. Additionally, the strength of these relations may grow with age.

It has been reported that regular PA, depending on its type, lowers arterial blood pressure by 2–11 mm Hg [2]. According to Knieć et al. [18] it can lower systolic blood pressure (SBP) by 8 mm Hg and diastolic (DBP) blood pressure by 2.5 mm Hg. Indirectly it also contributes to the reduction of body mass [19], thus limiting dyslipidemia and insulin resistance [20]. It should be noted that reduction in body mass results in the lowering of SBP by 4.4 mm Hg and DBP by 3.6 mm Hg [21]. This is also confirmed by the Trials of Hypertension Prevention II carried out in people with high, but still within the normal range, blood pressure and increased values of body mass index (BMI), where lowering of SBP by 3.7 and DBP by 2.7 mm Hg was seen with a loss of 4.5 kg of body mass [20]. However, there are reports that only 18% of women and 50% of men in the 30–49 age group and 31% of women and 36% of men in 50–70 age group increase their PA after being diagnosed with HT [22], which is an issue.

Walther et al. [23] noted that even the diagnosis of HT did not produce positive lifestyle change. Similarly, Rosenzweig et al. [24] indicated that unhealthy lifestyles were more often observed in those with disease, as their presence increases the risk of developing HT and diabetes (DM). This should not be surprizing, since complying with the medical recommendations concerning PA is assessed negatively by as much as 48.5% of patients with type 2 diabetes [25], despite the research evidence that shows that regular PA has a statistically and clinically significant effect on VO_{2max} in Type 2 diabetic individuals [26]. Also, a 20-year longitudinal study by Carnethon et al. [27] showed that adult men and women who developed diabetes over 20 years experienced significantly larger declines in relative fitness versus those who did not. The study clearly indicated that poor fitness was significantly associated with diabetes incidence and explained largely by the relationship between fitness and BMI. Obesity and HT, the most severe NCDs, generate serious health damage, including a drop of the patients' physical fitness (PF). Addition of any new disease has consequences not only for individual health, but also for public health (for instance because of the costs of care for disabled individuals).

Thus, we have posed the questions – how significantly does the presence of another concomitant disease, namely DM (which is a common concomitant disease with obesity), adversely affect PF factors in patients with obesity and HT, and what is the role of current and future PA in this respect? What we hope to establish is that the presence of another disease depletes the patients' health resources, as shown by a significant drop of PF which is vital for ensuring mobility, independence at an elderly age, and efficiency in everyday life. We wish to show the importance of PA, show the relationship between PA and PF, and conclude that more attention must be paid to the importance of both PA and PH in prevention and therapy of NCDs. It is important especially in the light of the trend in non-pharmacological therapy of NCDs seen among both patients and physicians, that they are more willing to accept diet changers [28, 29] than to initiate and increase their PA.

The current study assessed the relationships between the current level of PA and PA in childhood and the level of PF of obese people aged 40 + with co-existing HT. Moreover, the study looked for differences in the relationships by sex, age and co-existing diabetes. Selected biochemical indicators were considered.

Methods

Study design and participants

The study was conducted in 2017/2018 in the Clinic of Internal Medicine, Metabolic Disorders and Hypertension in Poznan. The study included 82 patients aged 40 to 75 years of which 48 were women and 34 were men. The mean age of the participants was 54.1 ± 13.0 years. The criterion to qualify for participation in the study was a clinical diagnosis of obesity with co-existing HT in patient's history. The diagnostic survey method was used along with a questionnaire. The questionnaires were filled in individually in quiet surroundings in a separate room, and filling it took approximately 10 minutes. Body mass, height and waist data were collected by trained personnel with the use of anthropological instruments. Body height was measured to the nearest 0.5 cm using a portable stadiometer and body mass was measured to the nearest 0.1 kg using mechanical personal scales (Seco, CE). Waist circumference was measured to the nearest 0.5 cm using an anthropometric measuring tape (Baseline, CE). Body mass index, as a measure of body composition, was calculated as body weight/height^2 (kg/m^2). The data concerning diagnosed diseases (such as: DM, lipid metabolism disorders, atrial fibrillation, etc.), values of systolic and diastolic blood pressure, heart rate, body weight at earlier visits and the current results of laboratory tests (total cholesterol, HDL, LDL, triglycerides, glucose, sodium) were taken from the medical documentation of the patients. The fitness test was performed with each patient individually by trained personnel in a specially prepared room for physiotherapeutic care. For the test, a hand dynamometer (Lafayette Digital Hand Dynamometer) was used, and a sit-and-reach box to measure flexibility when sitting – flexibility was measured to the nearest 0.5 cm.

Physical activity

In order to assess the level of PA of the participating patients we used the International Physical Activity Questionnaire (IPAQ) - Last 7 Days Physical Activity Recall - which has been validated in multiple international settings and population groups [30]. Intensity of various types of physical activity associated with daily life, work, and leisure is evaluated in IPAQ questionnaire using the MET-min./week (metabolic equivalent of work – minutes per week) coefficient. MET values were calculated using the methodological procedure [31] for 4 PA levels identified: total, vigorous, moderate, and walking. Based on these results, three PA levels were distinguished in accordance with the study methodology [31], namely: high, sufficient, and insufficient.

Additionally, in order to collect information on PA of the patients in childhood and adolescence a short original survey was used which consisted of three parts. In the first part, similar to the screening question of Prohaska et al. [32] concerning PA of children and adolescents, the participants were asked how many days a week they spent in the past on PA in three respective age categories: 6–14, 15–17 and 17–19 years. The second part concerned information on sport disciplines in which they engaged in the past, and in the third part the respondents made a self-assessment of their attitude towards PA. Employing the results of this survey together with the results of the IPAQ questionnaire made it possible to compare the levels of current and past PA.

Physical fitness

Functional fitness was assessed using seven selected trials (Fitness Test). No standardised tool for the measurement of functional fitness of persons with obesity was found in the literature. In order to ensure health safety of participants, the authors of the test decided to perform two trials from the Senior Fitness Test (30 Second Chair Stand and 2-Minute Step-in-Place Tests), two trials from the EUROFIT test battery (Handgrip Strength Test and Sit-and-Reach) and three complementary trials (One Leg Stand Test, Wall Squat Test, Plank Test). The suggested battery of tests measures basic physical parameters related to the ability to function and perform everyday activities. By performing tasks relating to walking, climbing the stairs or getting up, it specifies the resources of strength, endurance, balance and flexibility. Additionally, it is safe and does not put the participant at risk of unfavourable health consequences.

Fitness Test:

1. 30 Second Chair Stand - tested lower body strength,
2. Handgrip Strength Test – measured maximum isometric strength of the hand and forearm muscles with handgrip dynamometer,
3. Sit-and-Reach – measured flexibility of the lower back and hamstring muscles with a box. The starting position was sitting with the lower extremities straight and the knee joints not bent. The task was to perform a maximum bend and reach as far towards the feet as possible. The participant was to reach and maintain this position for 1–2 seconds while the distance was recorded,
4. One Leg Stand Test – balance test – the participant was standing with legs together, toes forward, arms along, but not touching the body. Then the participant lifted one leg until the thigh and lower leg were at a

90-degree angle. The participant tried to maintain this position for 30 seconds. This was followed by the test of the other lower extremity,

5. Plank Test (Prone Bridge Test) – test of core muscle strength and stability. The test involves maintaining the position on forearms and toes, with the whole body lifted above the floor in one line. The result of the test was the number of seconds for which the correct position was maintained,
6. Wall Squat Test – tested lower body muscular strength and endurance. The participant leaned on the wall with feet placed at shoulder width, bent the knees at 90 degrees and attempted to maintain the position for 30 seconds. The results of the test were the number of seconds for which the correct position was maintained,
7. 2-Minute Step-in-Place Test (an alternative for 6-minute march test) – exercise tolerance assessment. The subject starts marching in place with their right leg, raising their legs alternately to an individually set height (mid-thigh) as fast as possible. To help keep the balance, leaning against a wall, a chair, or a table is allowed. Final result is the number of right leg raises in 2 minutes [33].

Ethics

The research protocol was approved by the Local Bioethics Committee of the Karol Marcinkowski University of Medical Sciences in Poznan (decision no. 537/17). Participation in the study was free, voluntary and anonymous. Participants could withdraw from the study at any time without explanation.

Data analysis

Basic and advanced statistical procedures of the STATISTICA 13.3 (Stat.Soft, Krakow, Poland) software package were used to conduct data analysis. Statistical significance was set at $p < 0.05$. Because the distribution of quantitative variables was not normal the following non-parametric tests were used for statistical calculations: Mann-Whitney U test, Kruskal-Wallis ANOVA test, repeated measures ANOVA test, two-way ANOVA test and Spearman's rank correlation significance test.

Results

The minimum value of BMI, both for men and for women, was 30 kg/m^2. The mean value of BMI in women was 39.06 kg/m^2 and was higher than in men (37.54 kg/m^2), whereas for the whole studied group it was 38.43 kg/m^2. Also, the waist circumference values were similar: 150 cm in women and 157 in men, respectively. Taking into account the degree of obesity the largest number of patients (39%) had 3rd degree obesity and the smallest number of patients in the studied group (28%) had 2nd degree obesity. 1st degree obesity characterised 33% of the participants. Anthropometric data are presented in Table 1.

Table 1
Descriptive statistics of BMI, waist circumference, mean annual decrease/increase in body weight of the patients, blood pressure and HR values and results of laboratory tests of blood and their differentiation by gender, age, and presence of DM

Parameter	**Mean (SD)**			***p***	***p* (age < 60/>59)**	***p* (diabetes)**
	Female n = 48	**Male n = 34**	**Total n = 82**	**(F/M)**		
BMI, kg/m^2	39.06(6.78)	37.54(6.73)	38.43(6.76)	0.325	0.103	0.366
Waist circumference, cm	116.90(15.62)	121.79(16.84)	118.93(16.22)	0.190	0.559	0.049
Mean annual decrease/increase in body weight, kg/year	0.01(4.78)	0.64(3.13)	0.27(4.16)	0.728	0.475	0.296
Systolic blood pressure, mm Hg	143.30(12.88)	148.94(17.74)	145.63(15.25)	0.205	0.153	0.113
HR, 1/min	76.65(7.19)	77.50(6.78)	77.00(6.99)	0.399	0.002	0.121
Total cholesterol, mmol/l	5.80(2.34)	5.33(2.19)	5.63(2.28)	0.318	0.151	0.347
HDL, mmol/l	1.27(0.30)	3.28(10.12)	2.01(6.16)	0.351	0.899	0.571
LDL, mmol/l	3.42(1.14)	3.22(1.19)	3.35(1.15)	0.540	0.102	0.162
Triglycerides, mmol/l	2.09(0.99)	1.91(0.99)	2.03(0.98)	0.339	0.757	0.880
Sodium, mmol/l	140.77(2.57)	141.26(2.88)	140.95(2.68)	0.723	0.004	0.000
Glucose, mmol/l	6.98(2.67)	7.01(2.21)	6.99(2.49)	0.444	0.025	0.086

Note. *BMI*, Body Mass Index; *HR*, Heart Rate; *HDL*, High Density Lipoprotein; *LDL*, Low Density Lipoprotein; *SD*, standard deviation.

In the above parameters sex did not differentiate the participants, however age did in terms of resting HR, levels of glucose and sodium (lower parameters for younger participants, with the exception of the heart rate) and presence of DM in terms of waist circumference and glucose level (all parameters were lower for participants without diagnosed DM).

Also, the results of blood biochemical tests of 62 patients were analysed. Mean value of total cholesterol in the participants was 5.63 mmol/l (slightly higher in women than in men, 5.80 mmol/l and 5.33 mmol/l, respectively) and in almost half of the participants (45.1%) blood cholesterol levels exceeded the normal level. The levels of LDL cholesterol, triglycerides and glucose, 3.34 mmol/l, 2.02 mmol/l and 6.99 mmol/l, respectively, were also above normal in a large group of the participants. Only the levels of sodium were normal with a minimum value of 135.00 mmol/l. Normal values were also noted for HDL cholesterol in the vast majority of the participants, with the mean value of 2.01 mmol/l (Diagram 1).

Physical Activity

The results clearly showed that few participants undertake intensive physical exercise (28%) which allows for a more effective reduction of weight. Walking, defined as walking without a break for at least 10 minutes, a significant preventative factor, but definitely less effective in the context of body weight reduction, is preferred by a large majority of the participants (88%). Detailed data on the level of declared actual PA of the respondents are presented in Table 2. Men declared a significantly higher level of total activity and intensive activity. The current age of the participants and the presence of insulin-dependent DM did not differentiate the frequency of undertaking PA of various intensities.

Table 2
Various levels of PA of the participants by gender, age and diagnosed DM

Physical activity	MET-min./week	Female n = 48	Male n = 34	Total n = 82	*p* (F/M)	*p* (age < 60/ >59)	*p* (DM)
TOTAL, MET-min./week	Mean (SD)	1961.25 (2862.99)	3194.25 (3403.80)	2472.49 (3138.44)	0.048	0.781	0.677
	Median	371.25	1749.0	1287.0			
VIGOROUS, MET-min./week	Mean (SD)	611.67 (2023.29)	1625.88 (2676.57)	1032.19 (2355.16)	0.006	0.172	0.254
	Median	0.000	0.000	0.000			
MODERATE, MET-min./week	Mean (SD)	730.83 (1116.67)	523.53 (806.06)	644.88 (999.40)	0.381	0.481	0.172
	Median	400.00	0.000	300.00			
WALKING, MET-min./week	Mean (SD)	618.75 (841.46)	1044.84 (1311.87)	795.42 (1075.45)	0.223	0.391	0.853
	Median	371.25	511.50	371.25			

Note. *MET-min./week*, metabolic equivalent of work – minutes for the week. 1 MET - corresponds to the amount of oxygen consumed at rest and is equal to 3.5 ml of oxygen per kg body weight per minute; *SD*, standard deviation.

Repeated measures ANOVA showed a significant differentiation in the amount of MET-min./week obtained for particular activities (vigorous, moderate, walking) by men (with Greenhouse–Geisser correction F = 3.645, df = 1.41/46.66, p = 0.048) with significant grater amount of vigorous activity than moderate activity (Tuckey's HSD post-hoc comparisons p = 0.024) There were no such results among women.

The participants were also divided into three groups based on the levels of activity measured with the IPAQ questionnaire: insufficient, sufficient, high level, and relationships with PA in the past, the level of current PA, the level of obesity and biochemical parameters were sought. High level of PA was noted for 24.4% of the participants (18.8% of women and 32.4% of men), sufficient level was noted for 45.1% of the participants (43.7% of women and 47.0% of men), and insufficient level for 30.5% of the participants (37.5% of women and 20.6% of men).

Looking at PA undertaken in childhood and adolescence it can be stated that men were generally more active than women (in particular in childhood) and that the present age of the participants does not differentiate them in this respect, similar to co-existence of DM or the current level of PA (Table 3). However, a weak correlation was found between the level of activity in the past (for the youngest and the oldest age groups) with the current expenditure carried out in an intensive manner ($r = 0.22$, $p = 0.047$, $r = 0.24$, $p = 0.030$, respectively). This indicates a larger tendency to undertake intensive activity by persons who were active in childhood. However, the decline in daily activity with age is clear (Chi^2 Friedman's ANOVA ($N = 82$, $df = 2$) = 57.922, $p < .001$). The recommended daily dose of 60 minutes of PA in a week was undertaken by only 12.2% of the participants at the age of 6–14 years (33% at least 6 times a week) and in later years of life: at the age of 15–17 years – 9.8% and 28.1%, respectively, and at the age of 17–19 years – 8.5% and 18.3%, respectively.

Table 3
Characteristics of the level of PA (the mean number of days in the week with a minimum 60 minutes of activity per day) of the participants in childhood and adolescence and the differentiation by age, sex, presence of DM and the current level of PA

Age	**PA in childhood**	**Female n = 48**	**Male n = 34**	**Total n = 82**	***p* (F/M)**	***p* (age < 60/>59)**	***p* (diabetes)**	***p* (levels of PA)**
6–14 years	Mean (SD)	4.15(1.81)	4.97(1.61)	4.49(1.77)	0.029	0.539	0.881	0.115
	Median	5.000	5.500	5.000				
15–17 years	Mean (SD)	4.00(1.69)	4.62(1.72)	4.26(1.72)	0.108	0.654	0.996	0.477
	Median	4.000	5.000	4.500				
17–19 years	Mean (SD)	3.00(2.19)	3.82(1.95)	3.34(2.12)	0.067	0.128	0.569	0.407
	Median	3.000	3.000	3.000				

In other analyzed parameters (BMI, obesity level, waist circumference, blood pressure, HR values and results of laboratory tests of blood) current PA level did not differentiate studied participants (for all $p > 0.05$).

Physical fitness

The participants performed seven tests assessing selected fitness parameters. The differences between sexes, related to age, DM and the level of current PA for the tests are presented in Table 4. Generally, sex differentiate only the results of hand grip strength (men are stronger than women) and age differentiates most of the tests. The fitness of the participants declines with age. Similarly, DM is linked with a decline in fitness of the studied patients. The level of current PA differentiated the level of results of the participants in all fitness tests. Higher activity was related to better results in fitness tests (Table 4).

Table 4

Differentiation in the results of fitness tests by gender, age, presence of DM and the current level of PA of the participants

Fitness Test	Mean (SD)			*p* (F/M)	*p* (age < 60/ >59)	*p* (diabetes)	*p* (levels of PA)
	Female n = 48	Male n = 34	Total n = 82				
1. Chair Stand Test, number of repetitions	11.7 (9.31)	14.47 (9.49)	12.87 (9.42)	0.078	0.003	0.015	< 0.0001
2. Handgrip Strength Test, kg	10.44 (6.24)	19.12 (10.65)	14.04 (9.34)	< 0.0001	0.205	0.628	0.015
3. Sit-and-Reach, cm	11.42 (9.87)	11.22 (9.49)	11.34 (9.65)	0.996	0.0004	0.108	0.007
4L. One Leg Stand Test - left leg, seconds	11.31 (11.37)	15.21 (12.26)	12.93 (11.83)	0.241	0.012	0.024	0.002
4R. One Leg Stand Test - right leg, seconds	10.09 (11.31)	13.06 (12.25)	11.32 (11.73)	0.155	0.007	0.054	0.002
5. Plank Test, seconds	5.02 (7.33)	6.32 (8.93)	5.56 (8.01)	0.854	0.0001	0.004	0.029
6. Wall Squat Test, seconds	8.69 (10.01)	10.00 (9.58)	9.22 (9.79)	0.506	0.0001	0.015	0.004
7. 2-Minute Step-in-Place Test, number of repetitions	9.77 (11.23)	14.56 (16.47)	11.76 (13.76)	0.230	< 0.0001	0.030	0.024

Hence in the subsequent stage the relations between DM and the level of PA and the fitness were sought. The two-way ANOVA model was used. In the analysis of relations with reference to individual fitness tests no interactive relations were noted, only the main effect for individual qualitative factors. This may mean that each of them makes an independent contribution to improvement or decline in fitness of the studied patients (Table 5).

Table 5
Main effects and interactions effect of DM and PA on fitness tests - results of two-way ANOVA

Fitness test	Variables	df	F	*p*	η_p^2
1. Chair Stand Test, number of repetitions	PA	2	15.82	< 0.0001	0.294
	DM	1	6.34	0.014	0.077
	PA x DM	2	0.37	0.689	0.010
2. Handgrip Strength Test, kg	PA	2	2.75	0.070	0.068
	DM	1	0.03	0.867	< 0.001
	PA x DM	2	0.19	0.828	0.005
3. Sit-and-Reach, cm	PA	2	4.17	0.019	0.099
	DM	1	1.09	0.300	0.014
	PA x DM	2	0.31	0.736	0.008
4L. One Leg Stand Test - left leg, seconds	PA	2	6.44	0.003	0.145
	DM	1	4.75	0.032	0.059
	PA x DM	2	1.52	0.226	0.038
4R. One Leg Stand Test - right leg, seconds	PA	2	7.35	0.001	0.162
	DM	1	3.12	0.081	0.039
	PA x DM	2	2.24	0.113	0.056
5. Plank Test, seconds	PA	2	2.37	0.101	0.059
	DM	1	7.57	0.007	0.091
	PA x DM	2	0.73	0.485	0.019
6. Wall Squat Test, seconds	PA	2	6.36	0.003	0.145
	DM	1	7.38	0.008	0.090
	PA x DM	2	0.29	0.751	0.008
7. 2-Minute Step-in-Place Test, number of repetitions	PA	2	4.54	0.015	0.154
	DM	1	0.08732	0.769	0.002
	PA x DM	2	0.85751	0.430	0.033

Note. *DM*, diabetes, *PA*, physical activity level, η_p^2, partial eta squared.

Discussion

We believe that the current work is the first study to present differences in the level of PF depending on the level of PA of obese people with co-existing HT. Our studies indicate that the PF is probably not related directly to obesity of the participants or coexisting HT. Rather, the current PA, the deficiency of which determines low PF and/or HT, may be the critical factor. We noted that the higher the level of PA, the higher the PF – even in obese participants with HT. On the other hand, co-existing DM lowers almost all analysed parameters, both biochemical and fitness ones.

It should be noted that slightly higher results from ours (33.4% vs. 28%) in terms of vigorous physical effort were obtained by Biernat [34] in the study of 373 administrative, technical and manual workers only 10.5% of whom were obese, almost half of the subjects had normal weight (46.4%) and 33.5% were overweight. This comparison shows that the feature which characterises the population studied by us (diagnosed diseases in patients: obesity, HT, DM in some of the participants) and often the accompanying lowering of the life quality and health do not motivate the patients to undertake intensive physical exercise more often.

On the other hand, in the comparison of total energy expenditure with the results obtained by Biernat [34] slight differences should be noted for high levels of PA (24.4% vs. 20.3%) and moderate levels of PA (45.1% vs. 49%), respectively, whereas for lower levels of PA the results are almost identical (30.5% vs. 30.8%). It could be suggested that the fixed model of lifestyle in terms of PA is a highly stable variable and a factor such as disease does not modify it. The results also coincide with the findings of a comprehensive study of health of the Polish population in 2009, conducted by the Central Statistical Office [35]. We have to note, similar to the authors of the report [35] and Biernat [34], that the level of PA of Poles is low. For at least one-third of obese patients with HT the level of PA is insufficient to maintain health on an unchanged level, and for another one-half it is insufficient to meet the criterion of effective non-pharmacological therapy. Moreover, we noted that the participants who are currently physically inactive obese adults with HT were also children with low activity in the past. The recommended daily dose of PA was undertaken by a small percentage of children.

In terms of PF of the studied obese patients with HT, the highest level of fitness occurred in persons in the group with a high level of PA. All participants in the studied group were under constant medical supervision and their blood pressure level was maintained pharmacologically, therefore we could not show any relationship between PA and fitness and the level of blood pressure of the respondents. We observed however, that in obese people treated for HT, appropriate PA co-existed with high PF. These are two basic factors which offer a chance of a therapeutic success in such patients. At present the therapeutic mechanisms by which physical exercise decreases blood pressure in hypertensive patients are unclear. There are many important, different factors and mechanisms [36]. Diaz and Shimbo [37] list several probable mechanisms of the effect of PA on blood pressure, but we can add that the concurring factor may be fitness of the locomotor apparatus (motor fitness).

The study showed that there is no single causative factor which directly characterises patients with high blood pressure. We demonstrated however that PF, the appropriate level of which is a necessary pre-condition of successful HT therapy, is probably a consequence of current PA. The activity undertaken in childhood is not directly associated with health (including the level of blood pressure) or with PF in adult life. However, appropriate lifestyle in adulthood may be the effect of patterns of behaviour developed in childhood and adolescence. However, the studies of obese people with HT showed that the relation between PA in childhood and in adult life is not necessarily a rule.

In our study we noted that PF of obese patients with HT is significantly related to co-existence of DM. Of course, it is difficult to indicate a primary factor – DM or PF - within this study but it opens interesting avenues for further research. In addition, patients with two or three chronic diseases (obesity, HT and/or DM) have a greater illness/disease burden and are more disabled as they experience greater barriers to overcome to be physically active, compared with populations with one or two diagnosed conditions. Patients with multiple chronic diseases experience greater barriers to be physically active because they are more depressed and likely to have less vitality, probably because of the burdens of multiple treatment regimens, concerns about complications, poorer perceptions of health, having to take more medications. Thus, they may perceive lower levels of autonomy and perceived competence in dealing with it all [38]. Our study shows that the level of PA of obese people with HT is low and particular deficiencies in this respect are noted in people with additionally diagnosed DM. Patients with DM in the first years of their illness are often recommended to make lifestyle changes in the absence of noticeable diabetes-related symptoms or complaints. Van Puffelen et al. [39] observed that many patients do not seem to perceive their condition to be serious and postpone lifestyle changes until DM related complications appear. Fitness levels of youth with DM seem to be in the low range, with youth with type 2 diabetes having poorer fitness levels than youth with type 1 diabetes [40]. Our findings indicate the need to develop and implement better education programmes, than those available so far for people with diagnosed DM. Our patients had obesity and HT before but those who have another disease diagnosed – DM – are still characterised by the lowest PF. Of course, it cannot be conclusively shown that low PF is a causative factor of DM, but we have demonstrated the relations between these two variables.

Moreover, we noted that the level of fitness of our patients was relatively low. For example, patients studied by us performed on average 12 repetitions in chair stand tests, whereas 64 older adults (≥ 60 years) studied by Shahtahmassebi et al. [41] performed approximately 16 repetitions before undertaking exercise, and even 20 repetitions after 18 weeks of training. Roongbenjawan and Siriphorn [42] indicated that a low number of repetitions in this test may significantly increase the risk of falls, because people who reported falls were able to perform only approximately nine repetitions. People in the age group studied by us should perform more than 13 repetitions on average [43].

Low fitness of our patients was also demonstrated in co-ordination tests. In one leg stand their time was only approximately 12 seconds, which shows a weak functioning of the body balance system. Da Silva et al. [44] noted that subject aged over 60 years, living independently, with no falls in the past, can stay even 25 s (ranging from 6 to 74 s). The subjects also had very significant difficulties in correct execution of the 2-Minute Step-in-Place Test.

The functional fitness factors studied by us are listed as some of those that contribute to successful ageing [45].

One of the limitations of the study is a small sample size, but considering the specificity of the analysed factors (DM, HT and obesity) the sample size was still reasonable. Adding PF with a group specific tailoring of the tests, which is rare it this kind of research, should be considered as a strength.

The analysis shows that deeper understanding of causes of lower PF of obese people with HT and additionally DM is needed in order to recognise the motivation, or its lack, to participate in the therapeutic process. Without the patient’s cooperation, a doctor, physiotherapist and other persons involved in patient care may be ineffective.

Conclusions

Obese patients, particularly with concomitant HT and DM, should be provided with interdisciplinary care of not only physicians and dieticians, but also of physical activity specialists: physiotherapists or personal coaches. Presence of several concomitant diseases depletes the patients' health resources, generates a greater anxiety against and unwillingness to make changes in terms of PA with its underestimated protective role; PA, meanwhile, should be intensely included both in prevention and non-pharmacological treatment of NCDs. Our study clearly shows that presence of another concomitant disease, namely DM, in obesity with HT significantly reduces PF rates. Mere recommendations to increase daily amount of PA may be insufficient. Muscle tissue volume, prerequisite for adequate fitness and hence, self-dependency and lack of problems with self-care and activities of daily living, decreases with age. Consequences of the lack of adequate support in this area for the health care system and social services are vast, both in terms of financing (e.g. costs of therapeutic and corrective actions) and social costs (e.g. costs of care for a disabled person). Another challenge is to devise reliable PF tests dedicated for obese patients which should be included in assessment of the patients’ health resources. Educational messages addressed to people suffering from NCDs should also be significantly modified to emphasize the importance of daily, well-designed PA to improve PF. This is the purpose, among others, of the health-related fitness concept.

Abbreviations

WHO: World Health Organization; PA: physical activity; PF: physical fitness; DM: diabetes; HT: hypertension; IPAQ: International Physical Activity Questionnaire; NCDs: non-communicable diseases; SBP: systolic blood pressure; DBP: diastolic blood pressure; MVPA: moderate to vigorous physical activity; BMI: Body Max Index; HR: Heart Rate; HDL: High Density Lipoprotein; LDL: Low Density Lipoprotein, MET-min./week: metabolic equivalent of work – minutes for the week.

Declarations

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Not applicable.

Authors' contributions

J. Krzysztoszek and I. Laudańska-Krzemińska conceived the study design. J. Krzysztoszek and M. Karasiewicz were involved in data collection. I. Laudańska-Krzemińska and J. Maciaszek performed the statistical analysis. J. Krzysztoszek, M. Bronikowski, I. Laudańska-Krzemińska and J. Maciaszek interpreted data and prepared the manuscript draft. All authors edited, critically reviewed and approved the final version of the manuscript.

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Availability of data and materials

Please contact the corresponding author for data requests.

Ethics approval and consent to participate

The study was approved by the Bioethics Committee of the Karol Marcinkowski University of Medical Sciences in Poznan (decision no. 537/17). Furthermore, participants had been given adequate information about the purpose of the study. Individual personal information was kept confidentially.

Consent for publication

Not applicable.

Competing interests

The authors declare that there they have no conflicts of interest.

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Figures

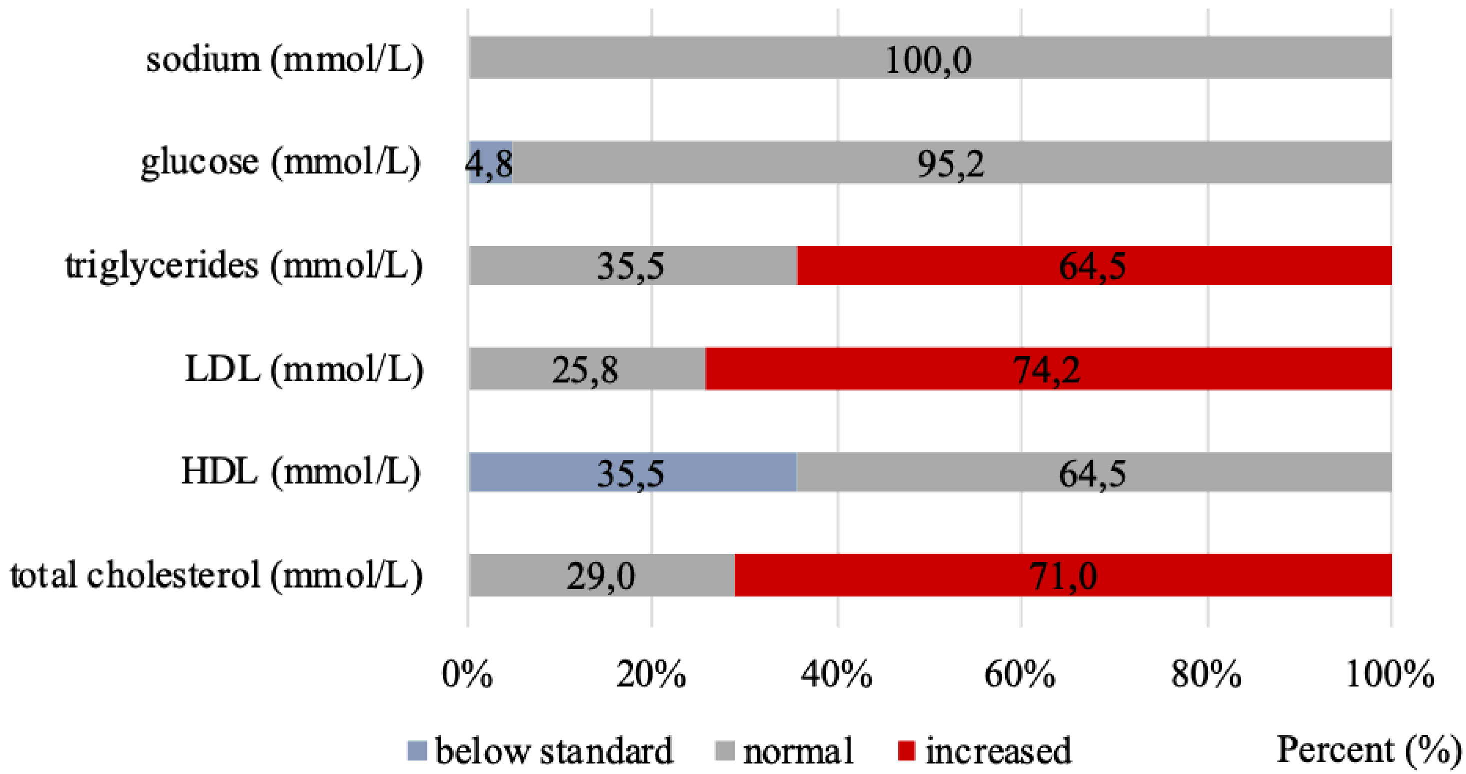
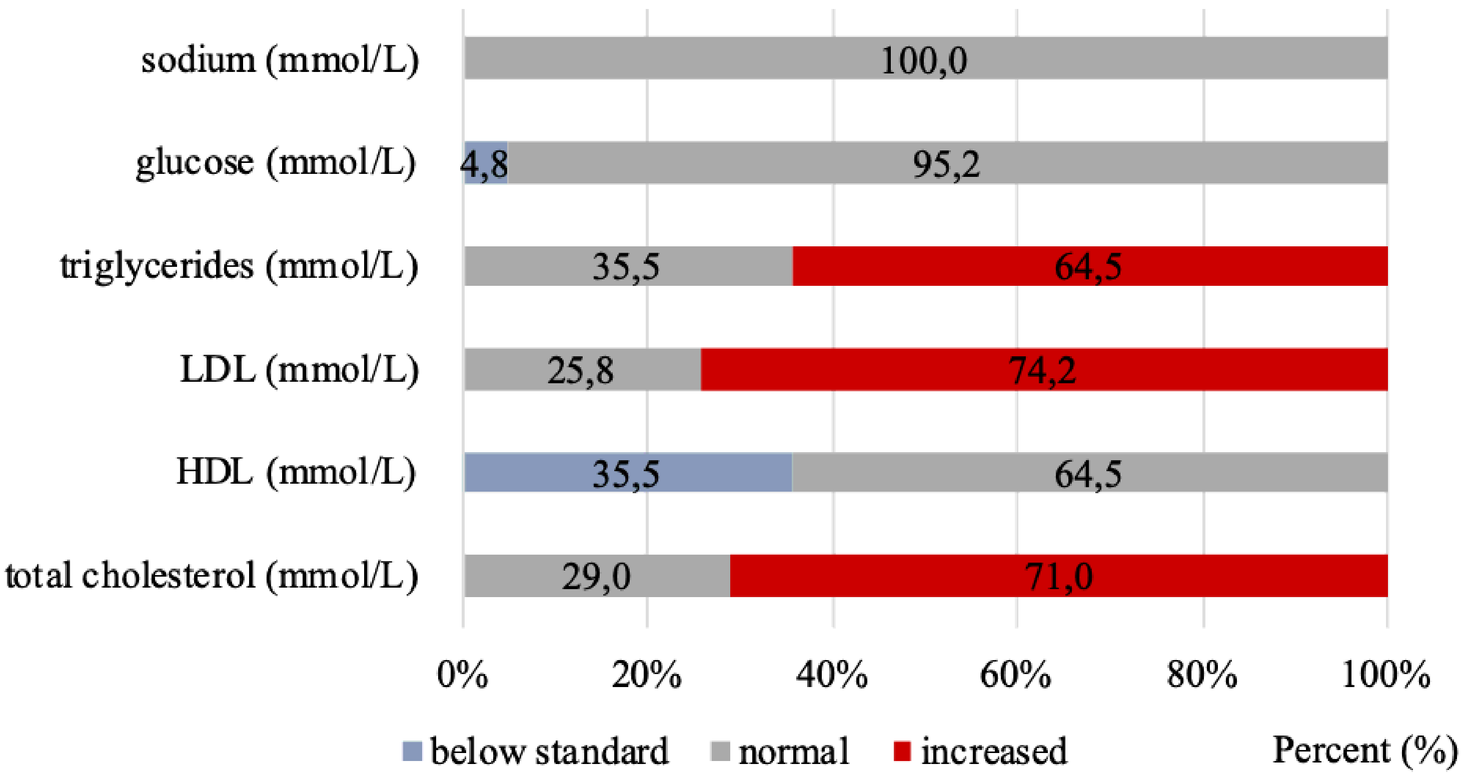


Figure 1

Analysis of results of blood biochemical tests in reference to normal levels of the parameters. Note. HDL, High Density Lipoprotein; LDL, Low Density Lipoprotein.



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