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The influence of sanatorium treatment of musculoskeletal disorders on reducing the amount of adipose tissue

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ABSTRACT

Introduction: In this article, the impact is analysed of sanatorium treatment on body composition in patients with musculoskeletal disorders. Adipose tissue plays a significant role in the development of metabolic disorders such as type 2 diabetes and cardiovascular diseases; therefore, reducing excess adipose tissue is an important element in the prevention and treatment of these conditions.
The aim of the article was to investigate the effects of the influence of sanatorium 21-day sanatorium therapy on changes in body composition, particularly adipose tissue and visceral fat, in the studied patients.
Materials and methods: The study was conducted on a group of 261 patients (117 men and 144 women) aged 36–89 years, participating in a 21-day sanatorium programme at the "Solinka" Sanatorium in Polańczyk. Changes in body composition were assessed using a body composition analyser, measuring body mass, fat content and visceral fat levels.
Results: The results showed significant changes in body composition after the 21-day sanatorium treatment. A reduction in body mass, decreased fat content, including visceral fat, and a lower BMI were observed. These findings suggest that sanatorium treatment for musculoskeletal disorders may also be an effective method for reducing visceral fat.
Conclusions: The 21-day sanatorium treatment results in changes in body composition, notably a reduction in adipose tissue. Among the interventions, massages and water exercises have the most statistically significant impact on reducing adipose tissue, underscoring their importance in the treatment program.
Keywords: sanatorium treatment; fat; musculoskeletal disorders.

INTRODUCTION

The objective of spa treatment is to treat chronic diseases using natural medicinal resources and appropriately selected treatments [1, 2]. The effectiveness of treatment is determined not only by the type, but also by the appropriately selected duration of therapy [3]. Balneological, physiotherapy and kinesiotherapy treatments have a training effect and improve many physiological functions, thus, accelerating regenerative processes in the organs. Spa therapy primarily leads to pain reduction, fitness improvement and increased resistance to stress [3, 4, 5]. A very important criterion for the effectiveness of the applied treatment methods is the so-called spa reaction as one that is adaptive, stimulating the long-term effects of metabolic processes [6, 7, 8, 9]. Occasionally, the final effect of the treatment depends on correct diet. A stay in a spa sanatorium lasts 21 days.

Adipose tissue is a deposit of energy reserves and has proven to be the largest endocrine gland. Histologically, adipose tissue is divided into white adipose tissue (WAT) and brown adipose tissue (BAT). As is known, excess visceral adipose tissue affects the development of metabolic complications [10, 11, 12]. Visceral tissue releases lipolysis products – free fatty acids – into portal circulation, intensifies hepatic processes (disrupts hepatic metabolism of insulin breakdown), and becomes the cause of hyperinsulinemia. Additionally, it increases the production of very low density lipoproteins (VLDL), leading to dyslipidaemia [10, 13]. Insulin resistance (IR) is one of the main causes of the metabolic syndrome development. In the case of excess visceral adipose tissue, the concentration of fatty acids is significantly increased. Peripheral tissues of the body prefer their uptake as a source of energy. The transport of glucose into the cells, which is dependent on insulin, is impaired. Cells accumulate and utilise acids more readily, which causes glucose to remain in the blood, leading to hyperglycaemia [10, 14, 15]. One of the organ complications of IR is non-alcoholic fatty liver disease (NAFLD). Adipose tissue actively participates in immunological processes through the cytokines produced in it, including interleukins 6, 12, tumor necrosis factor alpha (TNF-α), produced by macrophages, lymphocytes, mast cells and fibroblasts which migrate there. The presence of acute phase proteins is also observed: C-reactive protein (CRP), fibrinogen, albumin, transferrin and ceruloplasmin [16, 17, 18, 19]. In obesity, vessels follow the growing adipose tissue, which intensifies the migration and activation of macrophages, which results in increased production of cytokines and inflammation. It can be stated that in these individuals, a chronic inflammatory process is 'smoldering', which results in damage to many organs. Excess adipose tissue promotes the development of metabolic complications: obesity, diabetes or metabolic syndrome [10, 11, 14, 19, 20, 21, 22]. Increased activity of proinflammatory cytokines leads to increased blood clotting by increasing fibrinogen synthesis and also to damage of the vascular endothelium as well as activation of macrophages [23]. Macrophages accumulate excess lipids and transform into foam cells and then into atherosclerotic plaque. Recent decades have been rich in studies on the metabolic activity of adipose tissue, which is considered the largest endocrine gland in the human body and most of the adipokines produced by it take an active part in the development of inflammation [24].

Body composition testing using electrical bioimpedance analysis (BIA) is a sensitive, safe and inexpensive method [25]. Based on computer analysis of resistance measurements for individual body parts, information is obtained on the distribution of extracellular and intracellular water and the extra-cellular water/total body water (ECW/TBW) ratio, thus, obtaining information on cell mass [26, 27, 28, 29, 30]. This method allows to determine the distribution of adipose tissue in individual body segments in detail, including visceral adipose tissue. It is also used to determine the distribution of muscle tissue and its proportions to fat. In practice, it has been widely used to establish body composition in healthy people at sports medicine and fitness clubs [31, 32, 33]. In clinical reports, it has been shown that BIA is used to determine health status in: anorexia, obesity, as well as neoplastic, heart and vascular diseases [27, 34, 35, 36, 37].

The aim of the study was to investigate whether a 21-day sanatorium stay, causes changes in the body composition of the patients and whether the amount of adipose tissue of the subjects changed as a result of the applied balneological treatments. Due to the coexistence of diseases such as diabetes, hypertension, overweightness and obesity in the subjects, it was also decided to check whether the applied therapy had an effect on visceral adipose tissue content due to its role in the etiopathogenesis of these diseases.

MATERIALS AND METHODS

The study included patients undergoing spa treatment at "Solinka" Sanatorium in Polańczyk Zdrój. Persons qualified for the study underwent a 21-day spa stay. The study group consisted of 261 patients, of both sexes, aged 39–89 (mean age: 64.76 years; median age: 65 years), referred to spa treatment due to musculoskeletal disorders and coexisting diseases. Patients followed, depending on the indications, a standard, easily digestible, or diabetic diet. The average caloric value was 2225.8 kcal for the standard diet, 2105.2 kcal for the easily digestible diet, and 1937.0 kcal for the diabetic diet.

Examination with the Tanita MC-780 MA-N multi-frequency bioelectrical impedance analyser was performed at the beginning (on the second day) and at the end of the stay (on the last day). The tests were conducted cyclically from December 2022–June 2023 at the Physiotherapy Diagnostics Laboratory of the Natural Medicine Institute of the Sanatorium "Solinka" in Polańczyk. Measurements were always performed in the morning between 6:00 and 9:00 a.m., on an empty stomach and after urination. The plan of physiotherapy treatments was determined during initial medical examination by the balneologists of this centre, and was adapted to the treatment of the musculoskeletal system. The selection of treatments also took the age of the subjects and the occurrence of comorbidities into account: diabetes, hypertension, overweightness and obesity. This data was obtained from referrals to the sanatorium. The balneological procedures used in the treatment of this patient group included upper and lower limb whirlpool baths (10–20 min), full brine baths (10–15 min), group pool exercises (15–30 min), mud suspension baths (10–20 min), wet and dry carbonic acid baths (10–15 min), local mud compresses (20 min), and crenotherapy (125 mL, 3 times daily, 30 min after meals). The physiotherapy procedures included diadynamic currents, laser therapy, inhalation therapy, and massage (classical manual, mechanical, and lymphatic). All massages were partial and lasted 10–15 min. Additional interventions included local CO_2 cryotherapy, ultrasound therapy, low-frequency magnetic field therapy, TENS, Nemec currents, Trabert currents (Ultra Reiz), and Sollux infrared lamps. Kinesiotherapeutic procedures were also employed, including individual and group general rehabilitation, active exercises, breathing exercises, active unloading exercises, morning gymnastics, and Nordic walking. The minimum number of treatments prescribed for one patient was 54 for the entire duration of the spa treatment, while the maximum was 74 treatments. In addition, a survey was conducted at the beginning of the stay in the first examination, in which data was obtained on the occurrence of diseases, taken medications and lifestyle.

Statistical analysis

Statistical analysis was performed using the IBM SPSS 23 program. Compliance with the theoretical distribution was checked using the Kolmogorov-Smirnoff test ($n > 100$). Basic statistics were calculated depending on the nature of the variables. For quantitative variables, location measures (means) and dispersion (standard deviations) were estimated. For qualitative variables, the numerical and percentage distribution were calculated. Statistical hypotheses were tested using the Student's t-test (normal distribution) and Kruskal–Wallis' ANOVA (distribution inconsistent with that theoretical); χ^2 and MANOVA tests were applied for qualitative variables. The determination of factors that influenced the change in results between measurement points was performed using the multiple regression test. The p level was set at 0.05.

RESULTS

Characteristics of the study group

The study included 261 participants, 117 men (44.8%) and 144 women (55.2%). The average age was 64.76 years, the youngest participant was 36 years old, and the oldest was 89. Standard deviation totalled SD = 7 years. The majority of respondents lived in cities (n = 182, 69.7%), approx. 30% of respondents reported a village as their place of residence (n = 79, 30.3%). Most people reported that they were treated for chronic internal diseases (n = 190, 72.8%), which is presented in the table below (Tab. 1).

TABLE 1. Occurrence of chronic diseases in study participants

Variable	Study group (n = 261)	
Chronic diseases	n	%
Yes	190	72.8
No	71	21.2

Among the respondents, approx. 4/5 of the respondents (n = 205, 78.5%) reported taking medications on a regular basis due to chronic diseases (Tab. 2).

TABLE 2. Regularly taking medications among the study participants

Variable	Study group (n = 261)
Continuous use of medications	n
Yes	205
No	56

More than half of the respondents (n = 147, 56.3%) were individuals with confirmed diabetes and 176 (67.4%) were diagnosed with arterial hypertension (Tab. 3).

TABLE 3. Coexisting diseases in the study group

Variable	Answer	Study group (n = 261)	
		n	%
Diabetes	yes	147	56.3
	no	114	43.7
Hypertension	yes	176	67.4
	no	85	32.6

Comparative results between the first and second body mass index (BMI) measurement points

Patients were classified according to body mass index (BMI) into normal-weight (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2), obesity class I (30.0–34.9 kg/m^2), and obesity class II (35.0–39.9 kg/m^2) groups.

The study group differed statistically significantly depending on the measurement point ($p < 0.05$). The number of people after the stay at the sanatorium with second degree obesity significantly decreased (by 17 people, 54%) as well as among people with first degree obesity (by 12 people, 27%). On the other hand, the number of overweight subjects increased by 19 people (15%). The data is presented in the table below (Tab. 4).

TABLE 4. Comparative results (BMI) between the first and second measurement points

Variable	Study group 1st measurement point (n = 261)		Study group 2nd measurement point (n = 261)		χ^2
BMI (kg/m2)	n	%	n	%	
18.5–24.9	63	24.2	73	27.9	1.93
25.0–29.9	123	47.2	142	59	43.9
30.0–34.9	44	16.8	32	12.2	22.1
35.0–39.9	31	11.8	14	5.4	32.71

Influence of balneological, physio and kinesitherapy treatments on the change in body mass index based on the multiple regression test

The decrease in BMI after the stay was caused by 2 factors: exercises in the pool and massage (Tab. 5).

TABLE 5. Influence of applied treatments on the change in body mass index (multiple regression test)

Independent variable	Change in BMI F = (2, 46) = 417.53 p < 0.001	
Value	SE[a]	Beta[b]
Exercises in pool	0.321	2.222
Kinesiotherapy	0.162	0.093
Massage	0.265	3.394

SE[a] – standard error; Beta[b] – standardised coefficient b; p[c] – degree of test probability

Influence of spa treatment on body composition

Statistical analysis showed a significant reduction in body mass (difference of 0.18 kg, $p < 0.001$), fat percentage (0.1%, $p < 0.001$), fat mass (difference of 0.9 kg, $p < 0.001$), visceral fat mass (0.02 kg, $p < 0.001$), lean mass (0.18 kg, $p < 0.001$), BMI (0.09 kg/m^2, $p < 0.001$) after the sanatorium stay. These data are presented in the table below (Tab. 6).

TABLE 6. Influence of spa treatment on body composition

Variable	Study group before (n = 261)			Study group after (n = 261)			F K-W	p
Value	min/max	mean	SD	min/max	mean	SD		
Body mass (kg)	46.6/145.6	81.08	17.10	46.9/144.7	80.90	16.8	252.08	<0.001
Fat (%)	4.4/47.3	29.40	7.470	6.5/47.3	29.30	7.45	240.90	<0.001
Fat mass (kg)	2.6/58.4	24.30	9.400	3.4/57.0	24.21	9.30	245.80	<0.001
Visceral fat mass (kg)	2.0/26.0	10.05	4.339	2.0/25.0	10.03	4.30	244.30	<0.001
FFM (kg)	37.2/90.4	56.79	11.080	37.6/91.7	56.76	10.90	247.30	<0.001
Muscle mass (kg)	35.3/86.0	53.90	10.559	35.7/87.2	53.90	10.40	247.40	0.051
BMI (kg/m2 body)	17.8/41.7	28.89	4.783	17.8/40.8	28.80	4.67	250.40	<0.001

Change in fat mass after the applied sanatorium treatment based on the multiple regression test

The change in fat mass was dependent on the amount of pool exercise, as shown in the table below (Tab. 7).

TABLE 7. Change in fat mass after spa treatment (multiple regression test)

Independent variable		Change in fat mass $F = (2, 21) = 539$ $p < 0.001$
Value	SE[a]	Beta[b]
Exercises in pool	0.360	0.576

SE[a] – standard error; Beta[b] – standardised coefficient b; p[c] – degree of test probability

DISCUSSION

In recent years, diseases associated with excessive amounts of adipose tissue have been the subject of research on the border of medicine, public health and aesthetics. Both developed and developing countries are struggling with these problems [38]. Sanatorium treatment reduces pain and improves the general physical fitness of patients. The beneficial effect of sanatorium treatment in bone and joint diseases consisting in improving functional abilities, quality of life and reducing pain is the subject of research conducted by many authors [11, 39, 40, 41, 42]. The selection of the topic for this article was not accidental because it was considered whether the treatment of bone and joint diseases consistent with the sanatorium profile does not provide additional health benefits in the form of reducing adipose tissue, causing changes in body composition. The sanatorium stay also means a change in nutrition and lifestyle, which, together with the applied treatment, may have impact on changes in the subjects' body composition. Information from the survey confirms that during their stay at the treatment centre, due to comorbidities (Tab. 3), the participants were additionally recommended a diet, which was basic, diabetic and easily digestible.

The study group comprised 261 participants, the majority of whom were women (55.2%). The mean age of the individuals under study was 64.76 years. In the survey, 72.8% of people reported the occurrence of chronic diseases (Tab. 1) and ⁴/₅, i.e. 78.5%, reported taking medications on a regular basis due to comorbidities (Tab. 2).

The results of the research obtained using the Tanita BIA analyser proved that the 21-day stay in a sanatorium, thanks to the applied treatment of musculoskeletal disorders, reduced the body mass of the examined persons. The obtained BMI (Tab. 4) shows that this indicator decreased by 0.09 kg/m^2 and the result turned out to be of statistical significance ($p < 0.001$). As can be seen from the table, there was a significant 'reshuffling' of the examined persons before and after the stay, which was caused by the reduction in body mass. Prior the sanatorium stay, 24.2% of the participants were of normal body mass. The applied treatment increased the number of these people to 27.9%. Similarly, the number of overweight people increased (47.2–59%). This, in turn, reduced the number of people with first-degree obesity from 16.8% to 12.2% of the examined persons. The number of people with the second degree of obesity also decreased, from 11.8% to 5.4% of the entire group.

The multiple regression test applied for statistical analysis of the study results allowed to indicate which of the balneological, physiotherapy and exercise treatments had the greatest impact on the change in body composition. It turned out that the reduction in BMI was conditioned by 2 factors (Tab. 5). The first of them included pool exercise ($p < 0.001$) and massage ($p < 0.001$). These treatments are recommended as medical interventions by Chojnowski [37] in the treatment of obesity in spa conditions. Kinesiotherapy used during spa treatment did not have a significant statistical effect on the results ($p = 0.568$).

Comparing the results of the body composition analysis between the measurement points, it was observed that the average reduction in body mass among the subjects was 0.18 kg. This result turned out to be statistically significant ($p < 0.001$). Obesity is a civilization disease that affects contemporary societies all over the world. It is particularly related to insulin resistance and type 2 diabetes as well as cardiometabolic complications. Among the examined patients, as many as 75.8% demonstrated increased body mass prior to the treatment (Tab. 4). Insulin resistance very often precedes the occurrence of hyperglycaemia and is its initial phase [43]. It is estimated that approx. 85% of patients with diabetes have excessive body mass, while in 44%, obesity is responsible for the occurrence of type 2 diabetes [44, 45]. Importantly, mortality associated with excess body mass is definitely higher than that resulting from malnutrition [10, 14]. According to the research by Navarro-Gonzalez et al., in obese people additionally burdened with cardiometabolic risk factors and those with normal metabolic parameters, the risk of developing type 2 diabetes is significantly increased compared to slim or metabolically healthy overweight people [45, 46].

The change in body composition also caused a change in fat mass and in the present study, it mainly depended on the applied balneological interventions used, which were exercises in a swimming pool (Tab. 7). There is no data in the scientific literature on the effects of sanatorium treatment with regard to musculoskeletal diseases on the change in body composition, including fat reduction. However, it is known that physical training increases muscle mass and strength, which leads to increased energy expenditure, faster metabolism and reduction of excessive adipose tissue. This further results in a decrease in systolic and diastolic blood pressure, which reduces the risk of stroke and coronary heart disease. It improves the oxidative capacity of muscles and glucose tolerance, and reduces tissue insulin resistance [47]. Resistance training provides benefits in terms of blood lipid profile, reducing the amount of total cholesterol and triglycerides [48, 49]. Physical activity also has an anti-stress effect, because it affects hormonal changes in the body by removing stress hormones (cortisol and adrenaline), while simultaneously increasing the concentration of endorphins.

After the implemented sanatorium treatment, the percentage of fat in the body mass slightly decreased (Tab. 6) with a difference of 0.1%, however, this amount turned out to be statistically significant ($p < 0.001$). The average fat mass in the subjects for the second measurement point decreased and the difference was 0.9 kg ($p < 0.001$), which seems interesting due to the short period of therapy (less than three weeks) and that the majority of the subjects (75.8%) were overweight, obese, diabetic and taking medications on a regular basis. It should be noted that the reduction of adipose tissue also concerned visceral tissue, which, due to hormonal activity related to the production of adipokines, causes many complications in the cardiovascular system and the occurrence of diabetes and obesity [50]. This difference was 0.02 kg between the measurement points (Tab. 6) and this result also turned out to be of statistical significance ($p < 0.001$). Physical exercise is therefore an effective method of treating and preventing obesity and cardiometabolic disorders. It controls appetite and energy expenditure, while reducing inflammation and insulin resistance [47, 51, 52]. In a short period of time, after just a few physical exercises, genes stimulating the production of irisin in the muscles are expressed, triggering a cascade of metabolic processes and reducing adipose tissue [53]. Similarly, the effect of resistance exercise leads to a decrease in fat mass and leptin concentration [54, 55, 56]. Adiponectin produced by adipose tissue reduces the level of proinflammatory cytokines (TNF-α and interleukin 6) and, together with insulin, regulates glycolysis and glyconeogenesis, and has an effect on fasting glycaemia. It has been shown that adiponectin levels increase during convalescence following intensive aerobic exercise and strength training [57] in overweight people and those with fully-fledged type 2 diabetes. The exercise-induced increase in this adipokine resulting from the reduction of visceral fat mass improves oxidative metabolism and promotes lipolysis while having anti-inflammatory effects [51, 52, 58]. In the study by Cobbold, a decrease was also shown in resistin levels [59] after strength training. The reduction in inflammatory processes is attributed to a decrease in the number of adipocytes, which does not always have to be associated with weight loss. Taking the above into account, the changes in adipose tissue were small in the present study, but nonetheless, statistically significant, which may presumably cause changes related to metabolic processes in many tissues.

CONCLUSIONS

1. Sanatorium treatment of musculoskeletal disorders (21-day stay) led to a significant reduction in adipose tissue, including visceral fat, resulting in a decrease in body mass; the reduction in visceral adipose tissue amounted to 0.02 kg ($p < 0.001$).
2. Statistical analysis (multiple regression test) showed that the greatest influence on the loss of adipose tissue was the amount of pool exercises ($p < 0.001$) and number of body massages ($p < 0.001$).
3. To maintain the beneficial effects achieved during sanatorium treatment, patients should receive continued post-sanatorium care, including nutritional counseling and structured support for maintaining dietary habits and lifestyle modifications in their place of residence.

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