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Personalized Functional Nutrition and Lifestyle Intervention for Complex Metabolic Dysfunction: A Six-Month Case Report

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ABSTRACT

Coexistent dysfunctions of obesity, insulin resistance, chronic inflammation, thyroid dysfunction and poor quality of life may be hallmarks of chronic metabolic disease. Personalized functional medicine offers an approach to help patients heal their bodies through customized nutrition, lifestyle change and supplementation based on individual needs. Here, we report improvement of multiple metabolic and inflammatory dysfunctions in a female patient through personalized functional medicine. The patient is a 59-year-old female with a medical history significant for obesity, hypothyroidism, severe migraine headaches, chronic low back pain with bilateral leg radiation, nocturnal bilateral knee pain, chronic constipation, dyslipidemia, insulin resistance, likely fatty liver, and chronic inflammation. Initial labs showed abnormal results including HbA1c, fasting insulin, High sensitivity C-Reactive Protien, liver enzymes, lipids, thyroid-stimulating hormone (TSH), and ferritin. After six months of an individualized treatment plan including a whole-food anti-inflammatory diet, avoidance of inflammatory foods, a structured lifestyle plan, regular exercise, sleep hygiene, stress reduction techniques, and targeted nutrient supplementation, this patient had clinically significant reductions in body weight, body mass index (BMI), waist circumference, HbA1c, fasting insulin, liver enzymes, lipids, hs-CRP, TSH and ferritin. These positive laboratory changes were associated with improved metabolic function and well-being. This case study demonstrates improvement in multiple comorbidities with a personalized functional medicine approach and highlights the need for further research to determine its role in chronic disease management.

Keywords: Functional nutrition, Personalized nutrition, Obesity, Insulin resistance, Dyslipidemia, Chronic inflammation, Lifestyle medicine, Case report.

INTRODUCTION

Over recent years, there has been a significant increase in the prevalence of chronic metabolic conditions worldwide. Diseases such as obesity, insulin resistance, dyslipidemia, non-alcoholic fatty liver disease, and thyroid dysfunction have become leading causes of death and disability across the globe. [1] Many metabolic conditions are often found

alongside one another and share common pathological processes such as chronic inflammation, oxidative stress, hormonal dysregulation, impaired glucose tolerance, gut dysbiosis, and micronutrient deficiencies. Patients who suffer from these conditions also tend to have various overlapping symptoms like fatigue, myalgias, digestive issues, brain fog, which can be difficult to manage if each condition is treated separately. [2,3]

Standard medical treatment typically targets the diseases themselves or abnormal lab values with medication. Although pharmaceuticals can be very effective at reducing symptoms and controlling disease, they do not address all aspects of how diet, lifestyle, inflammation, metabolic health, and environmental toxins can influence disease processes. This is where functional medicine can play a role by targeting the physiology that becomes dysregulated with chronic disease. [4,5]

Functional nutrition aims to treat the root cause of disease by looking at how genes, lifestyle, nutrition, environmental factors, and biochemical imbalances can influence how the body functions. Treatment strategies typically include customized nutrition recommendations, increased physical activity, stress management, improved sleep, healing gut dysfunction, and supplement therapy. The goal of functional nutrition is to resolve symptoms by healing the body with the right nutrition and lifestyle changes. [6,7]

In this case report, we will be discussing a 59-year-old female with obesity, hypothyroidism, prediabetes with insulin resistance, dyslipidemia, possible metabolic dysfunction-associated fatty liver disease (MAFLD), chronic inflammation, chronic constipation, severe migraines, and chronic low back pain with radiation into both legs and bilateral knee pain at night. Labs at baseline showed abnormal glucose metabolism, dyslipidemia, inflammation, liver enzymes, hypothyroidism, and ferritin. The patient followed a 6-month individualized functional medicine plan that included a whole-food, anti-inflammatory diet, lifestyle modifications, protein optimization, nutritional supplementation, daily exercise, stress management, and sleep techniques. Anthropometrics, labs, and symptoms were tracked throughout the program to document improvements. Through this case report, we will demonstrate how a functional medicine approach can benefit multiple cardiometabolic abnormalities.

PATIENT PROFILE

A 59-year-old female presented with multiple chronic metabolic, musculoskeletal, and gastrointestinal complaints that had progressively impaired her quality of life and daily functioning. She had a known history of hypothyroidism and was receiving levothyroxine (25 µg/day). Comprehensive clinical evaluation and laboratory investigations revealed multiple metabolic and inflammatory abnormalities, prompting a personalized functional medicine intervention.

Patient Characteristics

- Age: 59 years
- Sex: Female
- Dietary Preference: Vegetarian
- Height: 164.7 cm
- Baseline Weight: 80 kg
- Baseline BMI: 29.5 kg/m²

BASELINE CLINICAL ASSESSMENT

Extensive history, physical examination, and laboratory testing revealed numerous overlapping metabolic, inflammatory, endocrine, liver, and digestive disorders. Overall, the patient's initial workup indicated that he had obesity, insulin resistance, chronic inflammation, hypothyroidism, hyperlipidemia, and abnormal iron regulation.

Table 1. Baseline Clinical Assessment

Clinical Domain	Key Findings
Anthropometry	Weight: 80 kg; Height: 164.7 cm BMI: 29.5 kg/m²
Glucose Metabolism	Fasting glucose: 101 mg/dL; HbA1c: 6.1%; Fasting insulin: 9.08 µIU/mL

Lipid Profile	Total cholesterol: 293 mg/dL; LDL-C: 204 mg/dL; Triglycerides: 227 mg/dL; HDL-C: 43 mg/dL; ApoB: 172 mg/dL
Inflammation	hs-CRP: 8.61 mg/L; ESR: 14 mm/hr; Elevated WBC and platelet count
Liver Function	Fatty Liver Index: 85; ALT: 40 IU/L; AST: 30 IU/L; GGT: 63 IU/L; ALP: 165 IU/L
Thyroid Function	TSH: 3.83 µIU/mL; Free T3: 2.3 pg/mL; Free T4: 0.98 ng/dL
Iron Status	Serum iron: 60 µg/dL; Transferrin saturation: 17.8%; Elevated TIBC
Complete Blood Count	Elevated RDW-CV, platelet count, leukocyte count, monocytes, and eosinophils
Renal Function	Low creatinine with preserved eGFR
Gastrointestinal Health	Chronic constipation requiring medication; persistent straining during bowel movements

From this initial assessment, it became clear that she was not suffering from one disease, but many metabolic abnormalities working together and causing her symptoms. Her symptoms and cardiometabolic risk factors were likely influenced by obesity, insulin resistance, dyslipidemia, chronic inflammation, hypothyroidism, sluggish liver function, disrupted iron regulation, and chronic constipation. Treatment strategies were implemented using therapeutic nutrition, lifestyle changes, and supplementation individualized to her specific metabolic imbalances.

INTERVENTIONS

The patient underwent 6 months of individualized functional nutrition treatment with the goal of reducing inflammation throughout the body, increasing insulin sensitivity, aiding thyroid and liver function, resolving nutrient deficiencies, healing the gut, and promoting weight loss. Recommendations were tailored to her history, labs, diet, and lifestyle. Recommendations included nutrition (therapeutic diet), nutrient timing, lifestyle, and therapeutic supplementation. [8,9]

Dietary Intervention

The primary strategy employed during the intervention was adoption of an anti-inflammatory, nutrient-rich, whole-foods-based diet. Dietary triggers of inflammation, metabolic disease, and dysbiosis were removed. [10,11] Plant-based foods were highly encouraged to restore metabolic flexibility, decrease oxidative stress, and address nutrient deficiencies. Diet was also tailored to promote regulation of glucose and lipids, gut healing, and improved physiology in a way that was compatible with the patient's vegetarian diet. [12]

Table 2. Foods Eliminated

Food Group	**Reason for Elimination**
Gluten-containing grains	To reduce potential gut irritation, intestinal permeability, and inflammatory responses.
Dairy products	To minimize digestive burden and potential inflammatory reactions in susceptible individuals.
Refined sugar	To improve glycemic control, reduce insulin secretion, and decrease systemic inflammation.
Refined seed oils	To reduce excessive omega-6 fatty acid intake and oxidative stress.
Soy products	Temporarily eliminated during the therapeutic phase to reduce potential dietary triggers.
Corn and corn products	Removed to reduce processed carbohydrate intake and simplify dietary elimination.
Ultra-processed foods	Eliminated due to their high content of refined carbohydrates, unhealthy fats, additives, and preservatives that contribute to metabolic dysfunction.

We also focused on incorporating nutrient-packed whole foods that were high in fiber, antioxidants, vitamins, minerals, and plant protein. These foods would help promote fullness, feed the gut microbiome, regulate blood sugar, and decrease inflammation. [13,14]

Table 3. Foods Encouraged

Food Group	Therapeutic Purpose
Lentils and legumes	Improve protein intake and glycemic control
Millets	Low-glycemic carbohydrate source rich in fiber
Seasonal fruits	Provide antioxidants and vitamin C
Vegetables	Improve micronutrient intake and gut health
Sprouts	Rich source of bioavailable protein and enzymes
Coconut	Healthy source of medium-chain fatty acids
Healthy fats (ghee, nuts, seeds)	Support hormone synthesis and reduce inflammation
Herbs and spices	Provide natural anti-inflammatory and antioxidant compounds

Meal Timing

In addition to eating healthier foods, the frequency and timing of meals were adjusted to enhance circadian rhythm, insulin sensitivity, and digestive health. Advised to start their day with water, eat breakfast with plenty of protein, not skip meals, eat meals consistently, and finish dinner early, this regimen aimed to help with blood sugar control, cut down on excess snacking, promote digestive health, and balance their metabolism. [15,16]

Key recommendations included:

- Morning hydration immediately after waking.
- Protein-rich breakfast to improve satiety.
- Regular meal timings without prolonged fasting or meal skipping.
- Early dinner to align food intake with circadian rhythms.
- Adequate hydration throughout the day.

Lifestyle Intervention

Lifestyle modification was also a critical aspect of treatment. As chronic stress, lack of sleep, sedentary behavior, and circadian dysfunction are all drivers of chronic metabolic illness, various behavior change techniques were employed to enhance overall physiological resilience.[17]

Table 4. Lifestyle Recommendations

Intervention	Expected Benefit
Morning sunlight exposure	Supports circadian rhythm and hormonal regulation
Grounding (earthing)	Promotes relaxation and stress reduction
Daily walking	Improves insulin sensitivity and cardiovascular fitness
Yoga and stretching	Enhances mobility and reduces musculoskeletal discomfort
Meditation and breathing exercises	Reduces psychological stress and autonomic imbalance
Sleep optimization	Improves metabolic recovery and hormonal regulation
Blue light reduction before bedtime	Supports melatonin secretion and sleep quality
Stress management practices	Reduces chronic inflammatory burden

Gradual introduction of regular exercise was implemented as tolerated based on functional capacity. Because her functional capacity was limited at baseline due to chronic back pain, her exercise regimen consisted of gentle movement, yoga, stretching, and increasing walking duration as tolerated as symptoms allowed. [18,19]

NUTRITIONAL SUPPLEMENTATION

Nutritional supplements were used to address specific micronutrient deficiencies and metabolic imbalances discovered throughout this process. Supplements were personalized for this patient based on initial lab work, symptoms, and recheck labs. Some of these supplements were used to help decrease inflammation, increase insulin sensitivity, support healthy thyroid and liver function, provide adequate energy through mitochondrial support, promote gastrointestinal (GI) health, and address other deficiencies. Supplementation was rechecked and amended throughout treatment. [20,21]

Nutritional supplements were utilized throughout the personalized treatment plan to further support dietary changes and

increase healthy lifestyle habits. Some supplements were based on this patient's symptoms, and others on lab work performed before, during, and after treatment. This patient used supplements to help decrease her inflammation, help her body become more insulin sensitive, and support thyroid and liver function. Other supplements were used to ensure she had proper mitochondrial function and energy levels, and gut health.

As discussed earlier, her labs indicated she could benefit from supplementing with nutrients to help support healthy metabolism. Continue with vitamin D3 and vitamin K2 to help support her immune system, balance calcium levels, and support bone health. In addition, they help to decrease inflammation as well. Supplement with omega-3 fatty acids to help with lipid metabolism. [22,23] This will help decrease the production of pro-inflammatory eicosanoids. Magnesium was used to help with glucose metabolism. It will also help with this patient's muscle and nerve function, as well as help her sleep better.

Supplement with vitamin B12 and iron to help increase red blood cell production [24]. This will allow for better transport of oxygen throughout the body and help with this patient's neurological function. Coenzyme Q10 will help support mitochondrial respiration and ATP production [25]. It also helps to prevent damage from free radicals. Lastly, use supplements to help support gut health. Probiotics will help with the good bacteria in this patient's gut. This will help with the digestion of food and allow the gut to better absorb nutrients.

Table 5. Targeted Nutritional Supplementation

Supplement	Therapeutic Purpose	Mechanism of Action	Timing
Vitamin D3 + Vitamin K2	Support immune function, bone health, and calcium metabolism	Vitamin D regulates immune and inflammatory pathways, while vitamin K2 promotes appropriate calcium utilization and prevents vascular calcification	As prescribed, with a fat-containing meal
Omega-3 Fatty Acids	Reduce systemic inflammation and improve lipid metabolism	EPA and DHA reduce pro-inflammatory eicosanoid production, improve membrane fluidity, and support cardiovascular health	With meals
Magnesium	Improve neuromuscular function, sleep quality, and glucose metabolism	Acts as a cofactor for over 300 enzymatic reactions involved in energy production, insulin signaling, and muscle relaxation	Evening or before bedtime
Vitamin B12	Correct deficiency and support neurological function	Essential for DNA synthesis, red blood cell formation, and normal nerve function	As prescribed
Iron (when indicated)	Improve iron stores and hemoglobin synthesis	Supports erythropoiesis and oxygen transport while correcting functional iron deficiency	Away from calcium-containing foods; preferably with vitamin C.
Coenzyme Q10	Improve mitochondrial energy production and reduce oxidative stress	Functions in the mitochondrial electron transport chain and acts as a potent antioxidant	With meals
Probiotic/Gut Support	Improve gastrointestinal health and nutrient absorption	Restores gut microbial balance, supports intestinal barrier integrity, and modulates immune function	As prescribed
Antioxidant Support (if indicated)	Reduce oxidative stress	Neutralizes reactive oxygen species and protects cellular structures from oxidative damage	As prescribed

Supplements were supportive of the healing diet and targeted at correcting physiological dysfunctions discovered during the discovery call. The labs were monitored

throughout the program to adjust supplementation if needed.

CLINICAL OUTCOMES

Anthropometric assessments, laboratory evaluations, and symptoms were assessed serially over the course of 6 months to monitor improvement. Positive trends were noted in measures of body composition, glycemic control, cholesterol, inflammation, liver enzymes, thyroid function, and iron levels. Symptomatically, she experienced a positive shift in her overall well-being and functional status.

She saw notable improvements in her body composition, including her weight, BMI, and waist circumference. Her weight trended down from 80.0 kg at baseline to 72.5 kg at 6 months, a total weight loss of 7.5 kg. Similarly, her BMI decreased from 29.5 kg/m2 to 26.7 kg/m2 and her waist circumference decreased from 39 in to 34 in. Overall, this represented a significant decrease in body fat, specifically visceral body fat.

Serial laboratory values demonstrated a positive change in glucose metabolism. HbA1c decreased from 6.1% to 5.8%. Fasting blood glucose normalized and both fasting insulin and C-peptide levels trended down from 12.0 uIU/ml to 7.0 uIU/ml and 3.21 ng/ml to 2.26 ng/ml, respectively. Together, these data suggest that her glucose metabolism was improving and she was at lower risk for progressing to T2DM.

Improvements were noted in several measures of cholesterol during follow-up. Total cholesterol, LDL, triglycerides, and apo B all decreased over the course of treatment. HDL increased slightly but did not reach optimal levels by the end of intervention. Despite some parameters remaining elevated, her overall cholesterol levels improved.

Trend data from markers of inflammation are displayed in Figure 3. CRP decreased significantly from baseline. Notably, WBC, eosinophil count, platelet count, and other markers of inflammation all decreased as well. Despite some markers remaining outside the normal range by the end of treatment, global reductions in inflammation were achieved.

Several biomarkers related to liver function improved throughout the intervention. Her FLI decreased from 61.1 at baseline to 33.4 by 6 months. ALT, AST, GGT, and LDH all decreased as well. These data support the hypothesis that her hepatic metabolism improved with treatment.

Thyroid function also improved slightly throughout treatment. TSH decreased and moved closer to the therapeutic range. Free T4 and total T3 remained within normal range. FT3 decreased slightly more but was combined with the patient's clinical improvement and current levothyroxine regimen, her thyroid panel suggests euthyroidism.

Serum iron increased from 53 mcg/dL at baseline to 71 mcg/dL at 6 months. Transferring saturation also increased from 15.2% to 22.6%. These results indicate that her iron levels and overall iron metabolism improved with intervention. Ferritin trended downward but remained within normal range.

PATIENT-REPORTED SYMPTOMS

The patient experienced improvements to several symptoms that had been affecting her quality of life. She experienced less shortness of breath when walking. She also noted less body aches, more regular bowel movements, and increased energy. These improvements were experienced alongside treatment for hypothyroidism and likely contributed to her overall improvements in sense of well-being.

Table 6. Improvements in parameters

Clinical Domain	Parameter	Baseline	Final	Clinical Interpretation
Anthropometry	Weight (kg)	80.0	72.5	Significant weight reduction
	BMI (kg/m²)	29.5	26.7	Reduced overweight status
	Waist Circumference	39	34	Reduced central adiposity

	(inches)			
Glucose Metabolism	HbA1c (%)	6.1	5.8	Improved long-term glycemic control
	Fasting Glucose (mg/dL)	101	95	Improved fasting glucose regulation
	Fasting Insulin (µIU/mL)	9.08	7.00	Improved insulin sensitivity
	C-Peptide (ng/mL)	3.01	2.33	Reduced insulin demand
Lipid Profile	Total Cholesterol (mg/dL)	293	253	Improved lipid profile
	LDL Cholesterol (mg/dL)	204	174	Reduced atherogenic cholesterol
	Triglycerides (mg/dL)	227	181	Improved triglyceride metabolism
	ApoB (mg/dL)	172	133	Reduced cardiovascular risk
Inflammation	hs-CRP (mg/L)	8.61	4.59	Reduced systemic inflammation
	Total Leucocyte Count ($\times 10^3/\mu L$)	8.43	7.32	Reduced inflammatory burden
	Eosinophils (%)	7.5	3.2	Reduced inflammatory activity
Liver Function	Fatty Liver Index	85.0	43.8	Marked improvement in hepatic steatosis risk
	ALT (IU/L)	40	27	Improved liver function
	GGT (IU/L)	63	23	Reduced hepatic oxidative stress
Thyroid Function	TSH (µIU/mL)	3.83	2.71	Improved thyroid regulation
Iron Metabolism	Serum Iron (µg/dL)	60	63	Mild improvement in iron status
	Transferrin Saturation (%)	17.8	22.5	Improved iron availability

DISCUSSION

This case report presents evidence that personalized functional medicine interventions may have the potential to positively influence multiple interrelated disease processes in patients with obesity, insulin resistance, dyslipidemia, chronic inflammation, hypothyroidism, and poor quality of life. Data following 6 months of individualized nutrition counseling and lifestyle changes, along with strategic nutritional supplementation, revealed improvements in anthropometrics, blood glucose metrics, lipid parameters, inflammatory markers, liver enzymes, thyroid function tests, iron parameters. While it would be inappropriate to draw definitive conclusions from a single case report, our findings add real-world support to the theory that identifying and modifying the root causes of disease can and should play a role in complementing traditional medical treatment. [4,9]

The most notable change was observed in weight, BMI, and waist circumference. Independent of how much weight was lost, weight reduction is associated with improved insulin sensitivity, decreased visceral fat mass, and decreased secretion of pro-inflammatory cytokines. Supporting this, reductions in HbA1c, fasting glucose, fasting insulin, and C-peptide also indicate decreased insulin resistance and lower insulin requirements. These results align with studies demonstrating that whole-food, plant-rich dietary patterns, increased physical activity, and personalized nutrition counseling programs can have positive effects on metabolic health and prevent conversion to diabetes mellitus type 2. [8,9,16]

Significant improvements were seen in blood lipid levels and inflammatory markers. Total cholesterol, LDL, triglycerides, ApoB, and hs-CRP all decreased over the course of treatment, indicative of reduced cardiovascular and inflammatory burden. The implementation of an anti-inflammatory dietary pattern, increased fiber intake from whole plant foods, reduced intake of ultra-processed foods likely played a large role in these reductions, as did increased physical activity and omega-3 supplementation. Similar effects of other anti-inflammatory diets have been observed among patients with chronic metabolic and inflammatory conditions. [10,14,22,23]

Finally, improvements were noted in liver enzymes and, to a lesser extent, thyroid and

iron metrics. The dramatic decrease in Fatty Liver Index in conjunction with decreases in ALT and GGT likely indicates improvement in hepatic metabolic function, which can often be seen with weight loss and reductions in insulin resistance. Similarly, normalization of TSH while maintaining euthroid thyroid hormone levels may be due to improved metabolic control as well as the traditional effects of increased levothyroxine. Finally, increases in serum iron and TF saturation may have been multifactorial, as a result of improved nutritional deficiencies, gut function, and decreased inflammation. [20,25]

Overall, an important strength of this intervention was its holistic, systems-based approach. Rather than targeting one abnormal lab value, clinicians targeted all aspects of health that could be optimized including diet quality, meal timing, physical activity, sleep, stress, gut microbiome, and nutrient deficiencies. Due to the interconnected nature of chronic metabolic diseases which often involve insulin resistance, inflammation, oxidative stress, and metabolic abnormality, treatment of the whole-person rather than single problems may have contributed to the positive results seen. This type of approach is central to the practice of both functional medicine and lifestyle medicine. [4,9,17]

There are several limitations to this case report. First, as a single patient case study without a control group or run-in period, no definite conclusions can be made about the effectiveness of the intervention. Each individual component cannot be parsed out to determine its effect on the patient's overall clinical outcomes. Additionally, levothyroxine was continued throughout the study period and diet, lifestyle, and nutritional interventions were started at the same time, so it is difficult to know the true effect of each therapy. Multicenter prospective studies and randomized controlled trials are needed to assess the efficacy and reproducibility of personalized nutrition and lifestyle interventions in patients with chronic, complex conditions. [4,8,9,17]

CONCLUSION

This case provides insight into how a personalized functional medicine approach may benefit those suffering from complex chronic metabolic conditions. After 6 months of treatment including therapeutic nutrition, lifestyle changes, and personalized nutritional supplementation, significant improvements were seen in anthropometrics, insulin resistance, lipidomics, inflammatory markers, liver enzymes, thyroid function, and ferritin. Functional improvements were also noted.

While we cannot draw widespread conclusions from a single case report, this study shows that the interrelated physiology driving disease should be targeted instead of individual disease markers. Personalized functional medicine, which includes a patient-centered team approach, may be considered as an adjunct to traditional care for patients with obesity, insulin resistance, chronic inflammation, and more. More prospective analysis and clinical trials are warranted.

Declaration by Authors

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