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Original Research

The effect of intermittent diet and/or physical therapy in patients with chronic low back pain: A single-blinded randomized controlled trial

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ABSTRACT

Background and purpose: This study aimed to investigate the effect of intermittent diet and/or physical therapy in patients with chronic low back pain.
Materials and methods: Sixty sedentary volunteers with chronic low back pain participated in the study. Body weight and body mass index (BMI) were measured. Pain severity was assessed using Visual Analogue Scale (VAS) and Leeds Assessment of Neuropathic Symptoms and Signs (LANSS), while assessment of disability was done using Barthel Index (BI).
Results: The weight and BMI were reduced after treatment with diet only and diet plus physical therapy ($p < 0.001$). The pain severity was reduced in all the treated groups ($p < 0.001$), while BI was increased in the group treated with only physical therapy ($p < 0.001$).
Conclusion: The present study indicated that intermittent diet and/or physical therapy are beneficial to patients with chronic low back pain in terms of pain sensation and daily activities.
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Introduction

Chronic low back pain (LBP) may occur as a result of disruption of intervertebral discs, facet joints, nerve, muscle, ligament and fascia structures and lasts for more than 3 months.[1] LBP affects all age groups (from children to the eldery population) and is generally associated with sedentary occupations, smoking, obesity, and low socioeconomic status. LBP is an important and costly health challenge in worldwide.[2] The most expensive types of treatment for LBP are physical therapy (PT) (17%), inpatient treatment (17%), drug therapy (13%) and primary health care (13%).[3] Opioids are frequently used for treating chronic low back pain. Besides being addictive, opioids have side effects such as sedation, dizziness, depression and hypogonadism.[4] Exercise, manipulation, massage, superficial and deep temperature agents, transcutaneous electrical nerve stimulation (TENS) and ultrasound therapeutic (US) are among the non-invasive PT modalities for treating chronic LBP.[5] TENS is safe and easy modality that utilizes an analgesic mild electrical current for treatment of pain associated with musculoskeletal conditions.[6] However, the effects of TENS on pain are somewhat controversial. Some studies have reported that it reduces pain, while others reported that it has no pain relief effect.[7, 8] US is frequently used by physiotherapists in the treatment of LBP and is among the most widely used electro-physical agents in clinical practice.[9] A recent review reported that US, as a monotherapy, may not have a significant effect on functional recovery, but can be used with other non-invasive treatment modalities.[10] The use of traditional therapies for treating chronic pain is controversial and alternative strategies are needed to manage chronic pain.[11]

As at 2016, the World Health Organization reported an average of 650 million obese individuals worldwide. Obesity is a significant risk factor in diseases such as diabetes, cardiovascular disorders, musculoskeletal disorders, obstructive sleep apnoea syndrome and cancer (prostate, colorectal, endometrial and breast).[12] Evidence strongly suggests that obesity is common in chronic pain conditions and that pain complaints are common among obese individuals.[13] In a cohort study with 6796 adults, the frequency of LBP was found to be 3% among individuals with normal weight and 11.6% among obese individuals.[14] Weight loss in obese individuals may reduce their chronic low-back pain complaints.[15]

Dietary practices improve the quality of life and contribute towards weight loss.[16] An intermittent diet includes fasting and satiety during certain periods (days or weeks). In this diet, water is always made available and consumed.[17] An intermittent diet may

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lead to metabolic adaptations that favour a greater loss of fat mass, preservation of lean mass, and a greater ability to sustain weight loss.[18] In human studies, it has been demonstrated that severe calorie restriction (5:2 intermittent diet) for 2 consecutive days after normal feeding (5 days a week) may have more beneficial effects on metabolism compared to normal diets.[19] The intermittent diet may increase neurotrophic factors and brain plasticity in the central nervous system.[20] Deterioration of brain plasticity has been reported among the most important underlying causes of many chronic pain disorders including neuropathic pain, fibromyalgia, headache, chronic pelvic pain syndrome, LBP, shoulder pain and cancer pain.[21] Chronic pain is associated with hyperalgesia, allodynia and pro-inflammatory conditions, resulting in peripheral and central sensitisation which triggers spontaneous pain.[22] Pro-inflammatory mediators that sensitise nociceptors include cytokines, interleukins, tumour necrosis factor alpha (TNF-α), 5-hydroxytryptamine (serotonin), histamine, bradykinin, acidic pH, free radicals and eicosanoids (prostaglandins, leukotrienes and thromboxanes). Studies have documented that intermittent dietary administration reduces inflammation by suppressing pro-inflammatory markers.[23] These benefits indicate that an intermittent diet is a safe and cost-effective method for ameliorating health problems.

Although intermittent diet has positive effects on general health, no study has examined the effect of intermittent diet on pain and disability in patients with chronic LBP. This study aimed to investigate the effects of intermittent diet and/or PT in patients with chronic LBP.

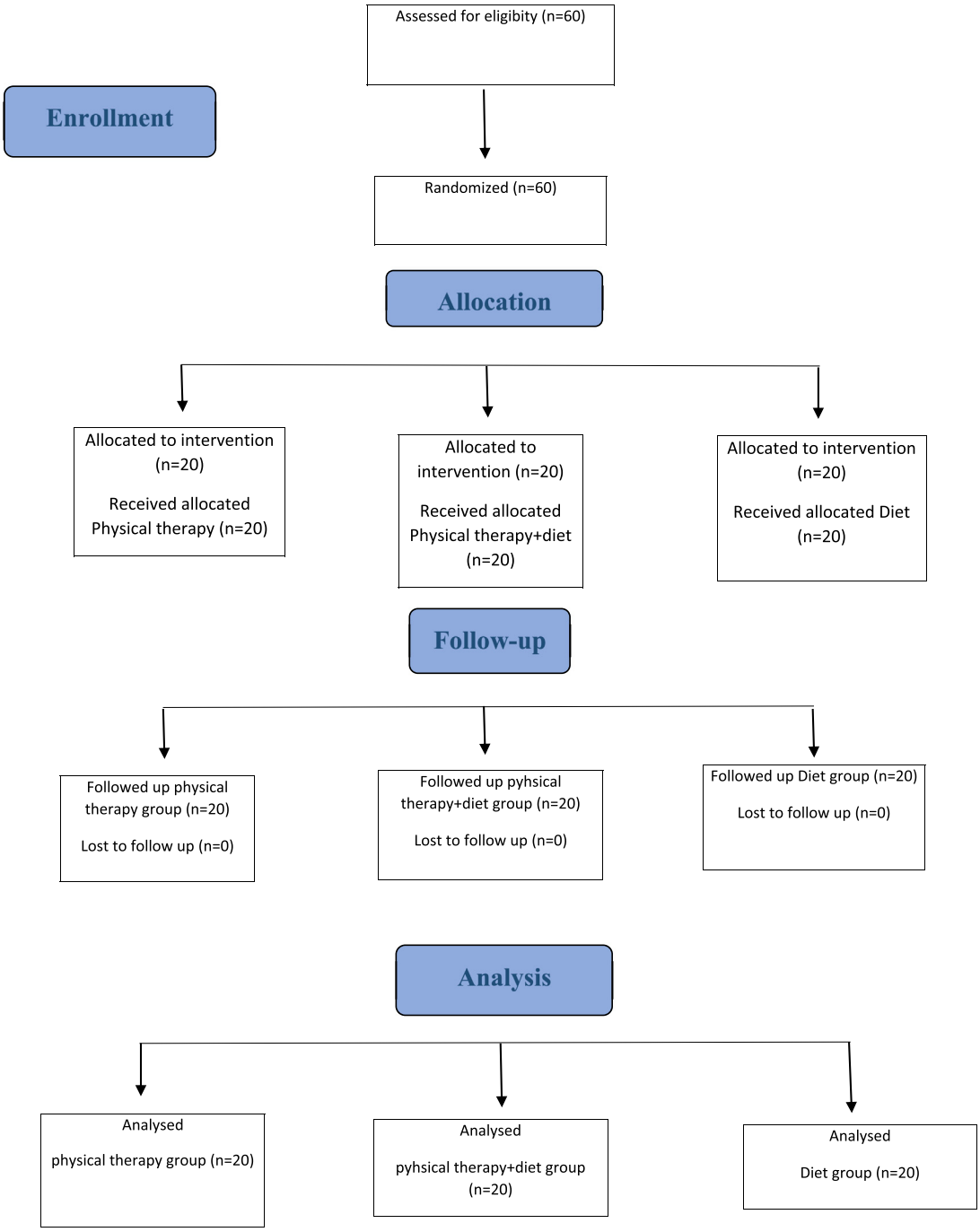

Fig. 1. The diagram describing the patient selection process and study flow

Materials and methods

Patients

This randomised controlled trial consist of patients with chronic LBP in the Physical Medicine and Rehabilitation Unit of a University Hospital from December 2018 to July 2019. Sixty (male = 30, female = 30) sedentary volunteers with chronic LBP (age range = 40–65 years) participated in the study. Magnetic resonance imaging was performed on patients with straight leg raise and who tested positive to Modified Schober Test (MST) following physical examination. MST is used to measure range of motion in studies on LBP.[24] While the patient was standing, fifth lumbar vertebra was marked. Then, 5 cm below and 10 cm above this point was marked (for a total of 15 cm distance). Then the patient was told to bend forward. The distance between the two marks was measured and 15 cm was subtracted from this measurement. MST was considered positive if the result is less than 5 cm. Patients with protrusion or non-compressed annular bulging and lumbar spondylosis were included in the study. The inclusion criteria were: patients with LBP for more than 3 months with pain severity of 5 or greater according to the visual analogue scale (VAS); and Body Mass Index (BMI) greater than 25 kg/m^2. Individuals who engage in active exercise; individuals who regularly take painkillers or anti-depressant and cortisone; pregnant individuals; and individuals having severe chronic illness and spine surgery were excluded from the study.

Sample size

The sample size calculation was done using a G*power analysis software Version 3.0.10 (G*Power, Franz Faul, Universität Kiel, Germany). It was calculated according to the previous study examining the effect of TENS and ultrasound on chronic pain.[25] Pain level was used to estimate the sample size. The analysis indicated that twenty participants for each group were enough to detect a large Cohen's effect (d = 0.75) with an alpha error probability of 0.05 and a power of 90%.

Randomisation and blinding

The diagram describing the patient selection process and study flow is shown in Fig. 1. The study was planned as single-blind. With the help of a computer program, patients were randomly divided into three groups: diet group (DG) (n = 20), physical therapy group (PTG) (n = 20) and diet + physical therapy group (D+PTG) (n = 20). To conceal the allocation, a statistician generated random allocation sequences using a computer random number generator and placed individual allocations in sequentially numbered and sealed envelopes which were given to the principal investigator who then utilised these envelopes to assign each new patient to a group and administered the appropriate intervention. The researcher who performed outcome measurements had no knowledge of the group assignment while performing the tests. When data entry was completed, the responsible researcher added the group assignment indicator variable to the dataset so that the statistician would analyse the data without knowledge of the group assignment and treatments.

Ethical considerations

The study protocol was approved by the Non-invasive Clinical Research Ethics Committee of the Faculty of Medicine, University of KTO Karatay on 19 December 2018. The study was conducted in accordance with the "Ethical principles for medical research involving human subjects" of the Helsinki Declaration. Before commencement of the study, detailed information about the study and its relevance was given to each participant and informed consent was signed by each participant.

Intervention

The body composition of the participants was measured by a dietician with Tanita BC 545 N Inner Scan TM with bioelectrical impedance analysis (BIA). The bioimpedance scale had a capacity of 150 kg, with precision of 0.1 kg for weight and 0.1% for fat mass percentage.[26] It had a criterion validity with dual-energy X-ray absorptiometry of r = 0.89.[27] The patients with chronic LBP and intermittent diet followed a diet programme prepared by a dietician after body analysis. On two consecutive days of the week, patients in the DG followed a diet program comprising 250 g of high protein food (lean chicken, fish and red meat or eggs), low-fat dairy products (low-fat 200 ml milk, 150 g yogurt and 30 g cheese), low carbohydrate vegetables or fruit, 1,200 ml low energised liquid and multivitamin supplement (approximately 600–700 kcal). In the remaining 5 days of the week, the participants applied the classic Mediterranean diet (1,500–1,700 kcal, 25% protein, 45% low glycaemic carbohydrate and 30% healthy fat).[28]

The diet programme lasted for 5 weeks; the first week was the adaptation week. The participants were interviewed face-to-face each day or through telephone and asked whether they were following the diet programme. The information obtained from the patients was recorded daily. In addition, a 7-day diet registration was completed by each participant per week and was checked weekly by the dietician.

The patients in the PTG were monitored 5 times a week for 5 weeks. Hot pack of 20 min TENS and 8 min US were performed on the waist area of patients in the PTG. TENS treatment parameters were: alternating current, rectangular impulse, impulse duration of 100 μs, frequency of 100 Hz and 20-min duration of a single treatment. US is used to deliver energy to deep tissue sites through ultrasonic waves which increase the tissue temperature or cause non-thermal physiologic changes.[29] For this study, the average local exposure time was one minute and effective radiating area of the transducer head was 5 cm^2. For a patient with LBP area of 40 cm^2, for instance, the required total treatment time is 1 min $\times$ (40 cm^2/5cm^2) = 8 minutes.[30] The continuous US was applied at a frequency of 1 MHz and a density of 2 W/cm^2. The patients in D+ PTG followed the same diet and PT programme as those in other groups for 5 weeks.

Outcomes

Body weight, height, BMI, VAS and Leeds Assessment of Neuropathic Symptoms and Signs (LANSS) (for evaluating the sense of chronic pain) and Barthel Index (BI) (for evaluating daily life activities) were obtained before and after the study. VAS is a unidimensional measure of pain intensity. The simplest VAS has a straight horizontal line of fixed length (10 cm). The ends are defined as extreme limits of the parameter to be measured (e.g. symptom, pain and health status), which is orientated from left (worst) to right (best).[31] LANSS was first applied by Bennett to clinically distinguish neuropathic pain from nociceptive pain. The application time is short and easy to evaluate. LANSS comprise a first part which is filled by the patient and a second part which includes a short physical examination by the physician. The first five questions answered by the patient has to do with their experience with neuropathic pain. In the physical examination part, the presence of allodynia is tested by touching the painful and painless area with cotton. The total score ranges from 0 to 24. If the score is $\geq$12, it is classified as neuropathic, while a score of $<$ 12 is classified as nociceptive pain.[32] BI is a sequential scale used to measure performance in daily living activities. Measurement of BI includes 10 personal activities such as feeding, personal toileting, bathing, dressing and undressing, getting on and off a toilet, controlling bladder, controlling bowel, moving from

wheelchair to bed and returning, walking on level surface (or propelling a wheelchair if unable to walk) and ascending and descending stairs. Each activity is evaluated between 5 and 15 points. The highest obtainable total score is 100,[33] which is used to assess disability caused by chronic LBP[34]

Statistical analysis

Results were considered statistically significant at $p < 0.05$ and all tests were two-tailed. Data were presented as mean ± Standard Error of Mean (SEM). Two-way repeated measures analysis of variance was performed to test for the main effects of groups (D+PTG, DG and PTG) and time (pre- and post-test), as well as interaction effect of groups and time. In addition, a simple effect test was performed for each group. All analysis was performed using JASP computer software Version 0.11.1 (JASP Team, 2019)

Results

The mean and SEM of demographic data of patients are presented in Table 1. The mean and SEM values of the variables before and after the intervention are presented in Table 2.

Age, body weight and BMI of participants

The mean age of participants in D+PTG was 54.30±1.38 years; 50.3± 1.64 years in DG; and 54.85±3.81 in PTG. Before and after treatment, the main effect of time on body weight was significant ($p < 0.001$). Also, there was a significant difference in body weight between the groups ($p < 0.001$) before and after treatment. There was a significant difference in body weight of D+PTG and DG when intragroup values were compared (D+PTG: $p < 0.001$; DG: $p < 0.001$). There was no significant difference in body weight before and after treatment in the PTG ($p = 0.330$). Before and after treatment, the main effect of time on BMI was significant ($p < 0.001$). There was a significant difference in BMI between the groups before and after treatment ($p < 0.001$). Before and after treatment, there was a significant difference in BMI of D+PTG and DG when intragroup values were compared (D+PTG: $p < 0.001$; DG: $p < 0.001$) There was no significant difference in BMI of PTG before and after treatment ($p = 0.330$). The body weight and BMI were expressed in kilogram (kg) and kilogram/meter^2 (kg/m^2), respectively.

VAS scores of participants

Before and after treatment, the main effect of time on the measurement was significant ($p < 0.001$). There was no significant difference between groups in terms of VAS scores before and after treatment ($p = 0.111$). There was a significant difference in VAS scores of each group before and after treatment when intragroup values were compared (D+PTG: $p < 0.001$; DG: $p < 0.001$; PTG: $p < 0.001$). VAS scores were expressed in centimetre (cm).

Table 1
The demographic data of subjects

	DG (n=20) (Mean±SEM)	D+PT-G (n=20) (Mean±SEM)	PTG (n=20) (Mean±SEM)
Age (years)	50.3±1.64	54.30±1.38	54.85 ± 3.81
Weight (kg)	89.81±2.83	88.44±1.75	83.23±3.29
BMI (kg/m^2)	33.23±1.32	32.91±0.80	30.2±1.05
Severity of pain	8.3±0.36	7.45±0.44	6.65±0.31
Sex	n	n	n
Female	10	10	10
Male	10	10	10

SEM: Standart Error Mean; BMI:Body Mass Index; n: Numbers of participants

Table 2
The variables of subjects before and after intervention.

P value Group	Pre-intervention	Post- intervention	intragroup	timeeffect
DG	89.81±2.83	85.74±2.76	<0.001*	
Weight (kg) D+PT-G	88.44±1.75	84.65±1.59	<0.001*	<0.001*
PTG	83.23±3.29	83.2±3.29	0.330	
DG	33.23±1.32	31.73±1.27	<0.001*	
BMI (kg/m^2) D+PT-G	32.91±0.80	31.5±0.74	<0.001*	<0.001*
PTG	30.2±1.05	30.11±1.05	0.330	
DG	8.3±0.36	4.7±0.41	<0.001*	
VAS (cm) D+PT-G	7.45±0.44	4.7± 0.42	<0.001*	<0.001*
PTG	6.65±0.31	3.1±0.38	<0.001*	
DG	4.8±0.88	2.3±0.59	<0.001*	
LANSS D+PT-G	10.6±0.88	7.1±0.76	<0.001*	<0.001*
PTG	5.1±0.43	2.6±0.36	<0.001*	
DG	97.5±1.80	98.75±1.02	0.135	
Barthel D+PT-G	98±1.28	99.5±0.50	0.083	<0.001*
PTG	90±2.25	94.8±2.07	0.011*	

DG:Diet group; D+PT-G:Diet+Physical therapy group; PTG:Physical therapy group; VAS: Visual Analogue Scale; LANSS: Leeds Assessment of Neuropathic Symptoms and Signs; BMI:Body Mass Index; * according to repeated measures ANOVA.

LANSS and BI of participants

Before and after treatment, the main effect of time on LANSS measurement was significant ($p < 0.001$). There was no significant difference in LANSS between the groups before and after treatment ($p = 0,134$). There was a significant difference in LANSS of each group before and after treatment when the intragroup values were compared (D+PTG: $p < 0.001$; DG: $p < 0.001$; PTG: $p < 0.001$).

Before and after treatment, the main effect of time on BI measurement was significant ($p = 0.001$). There was no significant difference between the groups in terms of BI before and after treatment ($p = 0.69$). There was no significant difference in D+PTG before and after treatment when intragroup values were compared (D+PTG: $p = 0.083$; DG: $p = 0.135$). There was a significant difference in PTG before and after treatment ($p = 0.011$).

Discussion

In our study, the effects of intermittent diet, PT and combined therapy for relieving pain and improving disability were investigated in patients with chronic LBP. The results indicated that pain sensation decreased in all groups and the quality of life of the patients increased after treatment in PTG. Intermittent diet may be an alternative option for the treatment of chronic pain.

Chronic LBP can be caused by many nociceptive and neuropathic factors such as facet joint syndrome, radicular pain, spinal stenosis and psychological factors. Therefore, in some studies on LBP, nociceptive or neuropathic distinction of pain sensation is important in the diagnosis and treatment.[21] In 85–90% of patients with chronic LBP, the pain is not due to anatomical disorder or pathology. However, in most of the cases, the source of pain is nonspecific.[35] Similarly, in our study, we used VAS and LANNS scales to assess pain sensation and determine the effect of treatment on pain sensation.

Exercise, tai chi, pilates, yoga, acupuncture, manipulation, massage, taping, US, TENS, temperature agents, nonsteroidal anti-inflammatory drugs (NSAIDs) and opioid painkillers are frequently used for treating patients with chronic LBP. A recent review reported that one treatment is not necessarily superior to another. It was further inferred in the review that it is beneficial to use a combination of

low-harm and low-cost treatment protocols on patients and that non-pharmacological approaches will yield positive outcomes.[36] Similarly, in our study, we employed non-pharmacological approaches such as US, TENS, temperature application and low-cost diet treatment together.

Fat ratio and BMI are often high in patients with chronic LBP.[37] Several studies have reported that obesity increases inflammatory markers in the body and causes pain sensation.[22, 38] Moreover, increased BMI in patients with chronic LBP causes increased fat infiltration in the paraspinal muscles (especially lumbar multifidus).[39] This relationship is important because changes in the paraspinal muscle composition can disrupt the support and control mechanism of lumbar muscles and cause pain.[40]

Decreased BMI may have a significant biomechanical effect on functional recovery in patients with chronic LBP. For instance, it was found that the rate of disability of patients with chronic LBP and BMI of >27 kg/m^2 increased by 16% in 1 year.[41] Clinically, intermittent fasting may be beneficial in age-related diseases such as rheumatoid arthritis, obesity and hypertension.[42] Although there are few studies on intermittent hunger programmes, the results seem promising.[43] Horne et al.[44] allowed participants (age range: 19–64 years) to drink water for a day and examined their acute biological responses. They observed positive metabolic and cardiovascular effects in short-term fasting. In another study, middle-aged male participants were divided into two groups: control group (n = 13) and calorie restriction group (n = 12). The daily energy need of participants in the calorie restriction group were reduced by 300–500 kcal/day for 2 days in a week for a duration of 3 months and their quality of life was examined. At completion of the study, they observed composition improvement, lower general body pain and increase in daily life quality in the calorie restriction group compared to control group.[45] In a study on obese and overweight premenopausal women, the participants' daily energy needs were reduced by 75% for 2 days in a week for a duration of 6 months, and during the other days of the week, they were fed normally. At completion of the study, a decrease in body weight and improvement in metabolic, inflammatory and endocrinal biomarkers were detected.[19] Intermittent fasting trials of 3 to 12 weeks in duration appear to be effective at reducing body weight (3%–7%), body fat (3–5.5 kg), total cholesterol (10%–21%), and triglycerides (14%–42%) in normal-weight, overweight, and obese humans.[46] Similarly, in our study, the BMI and body weight of participants decreased significantly in DG and D+PTG and, in both groups, a decrease in pain sensation was observed in the participants. These results reveal that the diet programme has a beneficial effect on the patients. When the BI of PTG and that of the other two groups were compared, the daily life activity better improved in PTG. Although the participants in DG and D+PTG lost weight at completion of the treatment, their daily life activity scores were low compared to that of participants in PTG. These results may be due to the fact that participants in these groups are still overweight compared to participants in PTG. It has been reported that obesity significantly inhibits activities such as crawling, walking and running, which are the simplest daily activities, even among young obese individuals.[47]

LANSS and VAS scores decreased in all groups. Several studies in literature have reported that electro-therapy improves chronic LBP. It has also been reported that the use of high frequency TENS is effective in patients with chronic LBP.[48] Furthermore, Jamison et al.[49] reported that high frequency TENS can improve the quality of life and reduce pain in patients with LBP . Ebadi et al.[50] demonstrated that continuous US reduces VAS scores in patients with chronic LBP. In another study, low intensity laser and continuous and pulsed US were applied to patients with chronic LBP and all three applications were observed to reduce pain.[51] Similarly, we used high frequency TENS and continuous US treatments in our study and observed a positive change in the VAS scores of PTG and D+PTG. US increases the flexibility of collagen fibres and circulation of connective tissues which aids functional restoration. It may be applied to decrease neuropathic pain.[52] In a randomised single-blind study, US combined with TENS were been shown to be effective in patients with chronic lumbar radiculopathy.[53] In a recent review, well-optimised TENS therapy was reported to be effective in neuropathic pain.[54]

In our study, LANSS and VAS scores were significantly lower in DG and D+PTG after treatment. This result is important because TENS and US treatments have been shown to reduce pain in humans, but the effect of intermittent diet has not been studied. This may be due to the positive effect of intermittent diet on inflammatory markers. Inflammatory response in the peripheral and central nervous systems play a key role in the development and persistence of many pathological pain conditions. Certain inflammatory cytokines in the spinal root are known to exhibit abnormal increases in injured or stuck posterior root ganglia.[55] Obese individuals have higher inflammatory markers because adipose tissue synthesises and releases various adipokines (leptin, adiponectin, resistin and visfatin) as well as pro- and anti-inflammatory cytokines (TNF-α, interleukin [IL] -4, IL-6, among other cytokines).[56] Finally, gut health and chronic pain are associated. The gut microbiome is a crucial modulator of visceral pain, however, recent evidence suggests that gut microbiota may also play a critical role in several other types of chronic pain including inflammatory, headache and neuropathic pain.[57] Moreover, studies have also reported that intermittent diet improves gut microbiota.[58] Dieting may lead to a decrease in inflammatory markers as well as improvement of gut microbiota which consequently decreases chronic pain.

Our study has several limitations. Firstly, no software program was used to check the diet records of patients. Subjective methods were used to assess the pain sensation and the selected region also included weight-bearing joints. Therefore, we could not determine whether the participants' pain sensation was due to weight loss or decreased inflammatory markers. Also we could not examine the gut microbiota. Another limitation in our study is the duration of the diet. In reviews on non-invasive PT, studies reported 2 to 5 sessions per week, usually for 1 to 4 weeks. In our study, since the PT and intermittent diet groups were linked, the intermittent diet duration was limited to 5 weeks.

Conclusions

We conclude that 5:2 intermittent diet and/or PT have a beneficial effect on pain sensation and daily living activities in patients with chronic LBP. Long-term efficacy of diet against pain associated with different pathologies; different diet types, different duration and different measurement techniques can be investigated in future large-scale studies.

Ethical approval

The study protocol was approved by the KTO Karatay University nonclinical research Ethics Committee (number:2018/012).

Declaration of Competing Interest

None.

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