International Journal of Research and Review
[Indexed, Peer-Reviewed Journal]
Volume 13; Issue: 5; May 2026
Website: www.ijrrjournal.com
Case Report *E-ISSN: 2349-9788; P-ISSN: 2454-2237*

Improvement of Chronic Musculoskeletal Pain, Gastrointestinal, Metabolic, and Thyroid Biomarkers through Advanced Diagnostic Testing and Functional Nutrition in an 11-Year-Old Female: A Paediatric Case Report

Anupriya Borah[1], Aakansha Tamhane[2], Saloni Kulkarni[3], Mugdha Pradhan[4]

[1]M.Sc., Researcher, ThriveTribe Wellness Solutions Private Limited, Pune, India
[2]M.Sc., Senior Functional Nutritionist, ThriveTribe Wellness Solutions Private Limited, Pune, India
[3]M.Sc., Head of Client Services, ThriveTribe Wellness Solutions Private Limited, Pune, India
[4]M.Sc., Expert Functional Nutritionist and CEO, ThriveTribe Wellness Solutions Private Limited, Pune, India

Corresponding Author: Anupriya Borah

DOI: https://doi.org/10.52403/ijrr.20260580

ABSTRACT

Background: Chronic musculoskeletal pain in children and adolescents can have a major impact on functioning and social participation. However, it has not received much attention from a research point of view. Musculoskeletal pain affects about 15-25% of adolescents, and frequent pain in adolescence may lead to chronic pain in adulthood. Conventional treatments focus on suppressing the symptoms but fail to address the underlying issues, often resulting in relapse and recurrence. On the other hand, functional nutrition addresses the root causes of the health disorder and helps heal the patient from within.

Case Presentation: This case report highlights the clinical course of an 11-year-old adolescent suffering from chronic pain in both legs, localized specifically between the knee and ankle, accompanied by fatigue, low energy, constipation and bloating. Comprehensive blood test and GI-MAP analysis reflected metabolic dysregulation, active *Helicobacter pylori* infection, and severe depletion of commensal species in the gut.

Intervention: A personalized functional nutrition-based protocol focused on gut microbiome restoration, pathogen elimination, and correction of nutritional deficiencies was implemented. The protocol emphasized following an anti-inflammatory and gluten-free diet alongside targeted supplementation and lifestyle modifications.

Outcomes: Following up after 90 days, the patient experienced a reduction in the severity of leg pain, correction of vitamin B12 deficiency, optimization of vitamin D, post-prandial insulin, free triiodothyronine (T_3) and thyroid-stimulating hormone (TSH) levels, and an improvement in platelet count. Her energy levels were restored, and fatigue also subsided.

Conclusion: The present case report highlights that a personalized functional nutrition-based approach can effectively address the root causes of chronic musculoskeletal pain in an adolescent and help understand the importance of advanced testing (such as GI-MAP) in paediatric patients with unexplained chronic musculoskeletal pain.

Keywords: Chronic pain, fatigue, functional nutrition, GI-MAP, supplements

INTRODUCTION

Chronic pain that persists or recurs for more than 3 months in children is one of the major clinical challenges, commonly associated with the child's physical, psychological, and social functioning (Tutelman et al., 2021). It is a rising health issue in children and adolescents that has detrimental effects on the individual, the family and the society (Miro et al., 2023). Epidemiological research is key to understanding chronic pain (Croft, 2010). A comprehensive review published in 2011 estimated that the median prevalence of chronic pain among children and adolescents ranged from 11% to 38%, depending on pain type and varied considerably across studies. Girls were found to have a higher prevalence of chronic pain, and also prevalence proportions increased with age (King et al., 2011). Recurrent lower limb pain is a prevalent symptom in the pediatric population, having a complex etiology that involves both physiological and pathological factors. Epidemiological studies indicate that 10-20% of children experience recurrent lower limb pain, with growing pains considered to be the most common nonpathological cause; the exact prevalence varies (Guo & Cang, 2026). Pain may be caused by infection through various mechanisms as a result of somatic (like septic arthritis) or visceral (like appendicitis) tissue invasion or neural injury (like acute herpes zoster neuritis) and the inflammatory process associated with it. Chronic pain can also be attributed to vaccine reactions, antimicrobial and surgical treatments (Cohen et al., 2022). In addition, different types of chronic pain may be influenced by gut microbiota through direct modulation of neuronal excitability in the dorsal root ganglia and regulation of neuroinflammatory processes in the central and peripheral nervous systems (Saeed et al., 2022). Gut microbiome is referred to as the "body's virtual organ," considering its significance in maintaining homeostasis. Gut dysbiosis has been increasingly recognized as a driver of numerous diseases in children, including functional gastrointestinal disorders such as irritable bowel syndrome and constipation (Avelar Rodriguez et al., 2021). It is interesting to note that there is a favorable link between gut dysbiosis and the development of neuropsychiatric disorders, as suggested by the preclinical and clinical data. Long-term gut dysbiosis results in altered neurotransmitter levels and overstimulation of the hypothalamic-pituitary-adrenal (HPA) axis and the neuroimmune system, leading to dysfunctional signal transduction, oxidative stress, inflammation, mitochondrial dysfunction and neuronal death (Anand et al., 2023). Children usually experience fatigue, yet it remains under-recognized and poorly treated (MacKinnon, 2023). A possible reason behind their fatigue could be attributed to a deficiency of micronutrients (Steenbruggen et al., 2015). Marginal or lower nutritional status is caused by a number of circumstances, including inadequate food quality or quantity, higher dietary requirements, increased metabolic losses, or impaired gastrointestinal digestion and absorption (Kiani et al., 2022). Functional nutrition offers a root cause-focused approach that moves beyond symptomatic management to identify and address the underlying health issues driving the disease. In the paediatric population, this approach has demonstrated success in managing conditions from inflammatory bowel disease to autism spectrum disorder. However, detailed evidence with respect to case studies documenting the application of functional nutrition protocols, especially in paediatric chronic pain in limbs linked to gut infection and dysbiosis, remains sparse. We report the case of an 11-year-old female who presented with chronic leg pain specifically localized between her knees and ankles for

over one-year, recurrent infections, and gastrointestinal issues. Comprehensive blood test and GI-MAP analysis revealed a complex microbial and metabolic profile. A structured and personalized functional nutrition-based intervention, delivered through the iThrive ALIVE program, resulted in clinically meaningful improvements across multiple domains within 90 days.

CASE PRESENTATION

The patient was an 11-year-old female from Bengaluru, India, with a height of 149 cm, weight of 39.5 kgs and BMI of 17.8 kg/m² (borderline underweight for her age) at baseline. She was presented to a functional nutritionist at ThriveTribe Wellness Solutions Private Limited, Pune, India, with over a year-long medical history of chronic leg pain, particularly localized between her knee and ankle. The pain was also accompanied by generalized fatigue, low energy after school, compromised immunity and gastrointestinal issues like constipation and bloating. She was administered enemas for stool evacuation. She was also under constant stress due to academic pressure. The dietary history of the patient depicted habitual consumption of non-vegetarian food with approximately 1.5 L of water intake daily. There was no documented history of previous endoscopy or colonoscopy, antibiotic regimen or surgery. The patient had no chronic illness diagnosed at the time of enrollment in the iThrive ALIVE program at the organization. Table 1 depicts the past medical history of the patient and the interventions followed thereafter.

Table 1: Timeline of Past Medical History, Diagnosis, Interventions, and Outcomes.

Date	**Relevant Past Medical History and Interventions**		
Aug 2025	**Age:** 11 years, Female **BMI:** 17.8 kg/m^2 **Current illness:** Presenting with chronic leg pain localized specifically between the knees and ankles, compromised immune system, digestive issues including constipation, bloating and fatigue **Previous diagnoses:** Chronic leg pain and gastrointestinal issues **Medication history:** Had painkillers for leg pain and vitamin D supplements for joint health prior to enrolling in the functional nutrition program		
	Summaries from initial & follow-up visits	**Diagnostic Testing**	**Interventions/Results**
Oct 2025	Enrolled in a functional nutrition program	Routine blood analysis revealed: Platelet count: 434 10E3/mm^3 Vitamin D: 71.1 ng/mL Vitamin B12: 210 pg/mL TSH: 0.41 µIU/mL Free T_3: 5.83 pg/mL Postprandial insulin: 54 µIU/mL GI-MAP revealed: Low levels of keystone commensal gut microbes like *Akkermansia muciniphila*, and high prevalence of *Helicobacter pylori* infection.	- Avoiding inflammatory foods such as soy, corn, gluten, dairy, sugar, processed foods, and refined oils - Consuming supplements such as Magnesium bisglycinate, B complex, vitamin D+K2, EAA, Krill oil-omega3, and zinc carnosine - Following evidence-based lifestyle interventions like maintaining sleep hygiene, reducing blue light exposure and incorporating grounding practices
Jan 2025	Follow up after 90 days and repeat blood tests	Repeat blood test reports revealed: Platelet count: 348 10E3/mm^3 Vitamin D: 28.7 ng/mL Vitamin B12: 714 pg/mL TSH: 1.27 µIU/mL Free T_3: 4.54 pg/mL Post-prandial insulin: 14.9 µIU/mL	- Chronic leg pain subsided - Energy levels restored - Digestive issues resolved - Gut infections improved - Continuation with the customized diet plan

Abbreviations: EAA, Essential Amino Acids; GI-MAP, Gastrointestinal Microbial Assay Plus; T3, Triiodothyronine; TSH, Thyroid-Stimulating Hormone.

She enrolled in the functional nutrition program at ThriveTribe Wellness Solutions Private Limited in October 2025 and her parents provided their consent for the treatment. Initial routine blood tests and subsequent root cause analysis revealed gut dysbiosis, recurrent infections, thyroid dysfunction and nutrient deficiencies. Table 2 shows the key abnormalities of the patient. Based on these parameters, the patient was recommended to follow a customized anti-inflammatory, low-FODMAP dietary protocol. Inflammatory foods eliminated included gluten, conventional dairy, sugar, seed oils, soy, corn, and all processed foods. The patient was transitioned to A2-milk dairy products, gluten-free grains (millets, quinoa, buckwheat, white rice), and a predominantly non-vegetarian, protein-rich meal structure. Specific preparation techniques were employed to mitigate microbial contamination of raw vegetables and pesticide burden on fruits. Lifestyle modifications included daily morning sunlight exposure, grounding (barefoot walking), oil pulling, tongue scraping, ozone water gargles, and blue-light restriction after 9 pm to support circadian rhythm regulation and cortisol normalization.

Table 2: Serum Analysis of Various Parameters at Baseline and Post-Intervention Protocol

Parameters	Baseline	Post-Protocol	Reference	Inference
Platelet count (10E3/mm$^{3)}$	434	348	162-317	Improved
Absolute Monocyte Count (10E3/µL)	0.33	0.37	0.36-1.0	Fixed
Eosinophils (%)	3.2	2.9	< 3	Fixed
Vitamin D (ng/mL)	71.1	28.7	4-33.6	Fixed
Vitamin B12 (pg/mL)	210	714	400-800	Fixed
Insulin, post-prandial (µIU/mL)	54	14.9	< 30	Fixed
Blood Urea Nitrogen (BUN) (mg/dL)	8.9	10.3	12-19	Improved
Triiodothyronine (T_3), free (pg/mL)	5.83	4.54	3.1-4.9	Fixed
Thyroid Stimulating Hormone (TSH) (µIU/mL)	0.41	1.27	0.5-2	Fixed

Advanced diagnostics using qPCR-based GI-MAP stool analysis (Table 3) revealed a complex picture of gastrointestinal infection and dysbiosis. The patient had an elevated *H. pylori* count and hence, this could be a possible reason for her frequent bloating and loss of appetite. In addition, the presence of *Staphylococcus aureus* and *Streptococcus* spp. in high amounts is associated with gut inflammation, decrease in digestive capacity, severe constipation and even dental health problems. *Akkermansia muciniphila*, a keystone commensal species as well as *Lactobacillus* spp. were critically low in the patient which altogether indicates serious intestinal dysbiosis and probiotic deficit alongside compromised lactic acid production.

Table 3: GI-MAP Analysis of the Patient

Marker	Reference	Result	Status
Helicobacter pylori	< 1.00e3	3.24e3	High
Akkermansia muciniphila	1.0e1 - 8.2e6	< Detection Limit	Low
Staphylococcus aureus	< 5.00e2	9.19e2	High
Streptococcus spp	< 1.00e3	1.57e4	High
Lactobacillus spp.	8.6e5 - 6.2e8	4.83e5	Low

Supplementation was initiated one product at a time to assess tolerability. The complete supplementation protocol is detailed in Table 4. Essential supplements (Magnesium Bisglycinate, B-Complex, Vitamin D3+K2, Krill Oil-Omega 3, Zinc Defense with L-Carnosine, EAA, Detox Binder) were maintained throughout. GI-MAP-directed supplements were introduced in four sequential phases:

Phase 0 (Gut lining repair): Gut Nutrients (Seeking Health, USA) and Forever Gut (Nutrazen, India).
Phase 1 (*H. pylori* and pathogen eradication): H. pylori Support (Zenmen, USA)
Phase 2 (Fungal/*Candida* eradication): Candida Support (Now Foods, USA)
Phase 3 (Gut dysbiosis treatment): Immune Support (iThrive Essentials, India)
Iron Bisglycinate (Unived, India) was deferred until after the *Candida* eradication phase to avoid providing a substrate for pathogen growth.
Persistent areas requiring continued intervention included low ferritin (9.75 ng/mL; Iron Bisglycinate initiated), low free thyroxine (T4) (0.94 ng/dL), high HOMA2-IR (2.5), borderline elevated glycated haemoglobin (HbA1c) (5.6%), and low albumin (3.98 g/dL), all attributed to ongoing infection burden and residual protein deficiency.

Table 4: Targeted Supplementation Protocol of the Patient

Name of the Supplement	Brand Name	Dosage
Magnesium Bisglycinate	iThrive Essentials, India	½ scoop (200 mg) with water twice a day, after breakfast and before bedtime
B complex	Doctor's Best, USA	1 capsule on alternate days, after breakfast
Vitamin D3+K2	iThrive Essentials, India	2 drops under the tongue, after breakfast
Krill oil-Omega 3	Jarrow Formulas, USA	1 capsule twice a day, with breakfast and dinner
Zinc Defense with L-Carnosine	iThrive Essentials, India	1 capsule, 2 h after lunch
EAA	iThrive Essentials, India	½ sachet, after breakfast
Detox Binder	iThrive Essentials, India	2 capsules, before bedtime
Iron Bisglycinate	Unived, India	1 capsule, 1 h after lunch
Immune Support	iThrive Essentials, India	2 capsules twice a day, after breakfast and before bedtime
Candida support	Now Foods, USA	1 capsule after breakfast
H. pylori Support	Zenmen, USA	1 capsule after dinner
Forever Gut	Nutrazen, India	1 capsule after dinner
Gut Nutrients	Seeking Health, USA	½ scoop in 200 mL of water

Abbreviations: EAA, Essential Amino Acids.

Additionally, the patient was also encouraged to inculcate journaling to organize her thoughts and manage stress. It was advised to her not to skip any meal and follow meal timings properly. She was asked to avoid sitting at one place for too long, take a 5-minute break every 45 minutes, and go for a short walk. Adding a pinch of salt to water before drinking and praying for the water to heal her body was made mandatory as a part of her daily routine. These minor interventions had a great impact on her lifestyle and led to a meaningful progression in both her physical and mental health.

DISCUSSION

The case report discusses the successful application of a tailored functional nutrition protocol in a paediatric patient with chronic pain in both legs for over a year, accompanied by gut infections, low immunity, energy depletion, and gastrointestinal issues like severe constipation and frequent bloating. Paediatric case reports using qPCR-based GI-MAP analysis as part of a functional nutrition programme are not very common, making this report a valuable contribution to the scientific literature.
The presence of *H. pylori* infection in a child this age is clinically significant. It is known to occur during childhood and affect more than half of the global population. In most cases, it shows no symptoms in children and even complications are rare (Aguilera Matos et al., 2020). *H. pylori* spreads by gastro-oral, oral-oral and faecal-oral routes, making transmission within the family a possible vector, while it may also spread due to poor hygienic conditions (Kayali et al., 2018). The patient in the current study had a critically low prevalence of *Akkermansia muciniphila* in the gut. It is a critical biomarker of intestinal

balance and metabolic health and its depletion is a characteristic of major gut dysbiosis that may lead to inflammatory bowel disease (IBD), obesity and diabetes (Khalili et al., 2024; Rodrigues et al., 2022). A mucin-degrading bacterium, *A. muciniphila,* promotes mucus production as well as expression of tight junction proteins, thus maintaining intestinal barrier integrity (Subburaj et al., 2026). Replenishing the growth of *A. muciniphila* through dietary polyphenols (such as apples, pomegranate, walnuts, and berries) and targeted supplementation represents a scientifically proven strategy that was incorporated into the present protocol (Rodríguez-Daza & de Vos, 2023).

The improvement in postprandial insulin level is particularly striking and could be likely due to the synergistic effect of eliminating inflammatory triggers, decrease in infection burden and improvement in mitochondrial function through EAA and B-complex support. The emerging concept that gut dysbiosis disrupts the intestinal epithelial barrier and causes immune dysregulation, subsequently affecting thyroid function, is supported by improvements in thyroid parameters (Free T3 and TSH). Gut microbiota plays a pivotal role in thyroid health, considering its strong influence over immune regulation, nutrient absorption and thyroid hormone metabolism (Jiang et al., 2025).

The phased, systematic approach to improve gastrointestinal issues in the patient, beginning with supplementation for gut lining repair before initiating antimicrobial supplements, depicts established functional nutrition principles of addressing foundational barriers before introducing eradication protocols. This sequence may reduce the risk of exacerbating symptoms through rapid bacterial die-off (Herxheimer-like reactions) and is consistent with approaches documented in adult functional nutrition case reports (Wood et al., 2026).

This case report also highlights the paediatric-specific consideration of deferring iron supplementation until after the *Candida* eradication phase, as iron is necessary for the physiological processes of bacteria and fungi (Caza & Kronstad, 2013). The subsequent decline in ferritin (from 21.3 ng/ml to 9.75 ng/ml) during the active pathogen eradication phase probably could be due to the competing demands of an inflamed gut with ongoing infection. This was actively addressed with iron bisglycinate in supplement form.

Furthermore, adopting certain lifestyle practices like regular exercise and meditation, journaling, maintaining sleep hygiene, getting sunlight for at least 5 minutes early in the morning and avoiding screens after sunset helped the patient manage stress and live a healthy life.

CONCLUSION

The case report underlines that a combination of both functional nutrition and targeted supplementation can yield significant clinical improvements across multiple health parameters in an adolescent having complex, overlapping pathophysiological conditions. After 90 days of being enrolled in the iThrive ALIVE programme, following the tailored functional nutrition protocol and exercising good lifestyle habits, the patient could achieve correction of vitamin B12 deficiency, normalization of vitamin D, thyroid axis optimization and improvements in erythrocytic indices. Most importantly, the chronic pain in both her legs subsided, her energy levels improved, and gastrointestinal issues, including constipation and bloating also reduced to a great extent. Avoiding inflammatory triggers, like gluten, dairy, sugar, etc. and consuming antioxidant-rich foods resulted in steady improvements in her overall health and well-being. Besides, this report also emphasizes the integration of advanced diagnostic testing such as GI-MAP into clinical practice, making it easily available for paediatric population living with digestive/gastrointestinal issues and metabolic dysfunction.

Supplementary:

Supplementary file is attached in the Abstract HTML page. Click here for supplementary file.

Declaration by Authors

Acknowledgement: None
Source of Funding: None

Consent to Publish: The consent was obtained from the patient's parents for publication

Conflict of Interest: The authors declare no conflict of interest.

REFERENCES

1. Aguilera Matos, I., Diaz Oliva, S. E., Escobedo, A. A., Villa Jiménez, O. M., & Velazco Villaurrutia, Y. D. C. (2020). Helicobacter pylori infection in children. In *BMJ Paediatrics Open* (Vol. 4, Number 1). BMJ Publishing Group. https://doi.org/10.1136/bmjpo-2020-000679
2. Anand, N., Gorantla, V. R., & Chidambaram, S. B. (2023). The Role of Gut Dysbiosis in the Pathophysiology of Neuropsychiatric Disorders. In *Cells* (Vol. 12, Number 1). MDPI. https://doi.org/10.3390/cells12010054
3. Avelar Rodriguez, D., Popov, J., Ratcliffe, E. M., & Toro Monjaraz, E. M. (2021). Functional Constipation and the Gut Microbiome in Children: Preclinical and Clinical Evidence. In *Frontiers in Pediatrics* (Vol. 8). Frontiers Media S.A. https://doi.org/10.3389/fped.2020.595531
4. Caza, M., & Kronstad, J. W. (2013). Shared and distinct mechanisms of iron acquisition by bacterial and fungal pathogens of humans. *Frontiers in cellular and infection microbiology*, *3*, 80. https://doi.org/10.3389/fcimb.2013.00080
5. Cohen, S. P., Wang, E. J., Doshi, T. L., Vase, L., Cawcutt, K. A., & Tontisirin, N. (2022). Chronic pain and infection: mechanisms, causes, conditions, treatments, and controversies. In *BMJ Medicine* (Vol. 1, Number 1). BMJ Publishing Group. https://doi.org/10.1136/bmjmed-2021-000108
6. Croft, P., Blyth, F. M., & van der Windt, D. (Eds.). (2010). *Chronic pain epidemiology: from aetiology to public health*. Oxford University Press (UK).
7. Guo, X. Q., & Cang, T. S. (2026). Clinical Screening and Factors Influencing Growing Pain in Children with Recurrent Lower Limb Pain: A Controlled Study on Symptom Assessment and Motor Load. *International Journal of General Medicine*, *Volume 19*, 1–12. https://doi.org/10.2147/IJGM.S565653
8. Jiang, T., Yang, X., Wu, B., Tao, R., Chen, R., Jin, L., Sun, D., & Weng, H. (2025). Gut microbiota in hypothyroidism: pathogenic mechanisms and opportunities for precision microbiome interventions. In *Frontiers in Microbiology* (Vol. 16). Frontiers Media SA. https://doi.org/10.3389/fmicb.2025.1661211
9. Kayali, S., Manfredi, M., Gaiani, F., Bianchi, L., Bizzarri, B., Leandro, G., Di Mario, F., & De'angelis, G. L. (2018). Helicobacter pylori, transmission routes and recurrence of infection: State of the art. In *Acta Biomedica* (Vol. 89, pp. 72–76). Mattioli 1885. https://doi.org/10.23750/abm.v89i8-S.7947
10. Khalili, L., Park, G., Nagpal, R., & Salazar, G. (2024). The Role of Akkermansia muciniphila on Improving Gut and Metabolic Health Modulation: A Meta-Analysis of Preclinical Mouse Model Studies. In *Microorganisms* (Vol. 12, Number 8). Multidisciplinary Digital Publishing Institute (MDPI). https://doi.org/10.3390/microorganisms12081627
11. Kiani, A. K., Dhuli, K., Donato, K., Aquilanti, B., Velluti, V., Matera, G., Iaconelli, A., Connelly, S. T., Bellinato, F., Gisondi, P., & Bertelli, M. (2022). Main nutritional deficiencies. In *Journal of preventive medicine and hygiene* (Vol. 63, Number 2, pp. E93–E101). NLM (Medline). https://doi.org/10.15167/2421-4248/jpmh2022.63.2S3.2752
12. King, S., Chambers, C. T., Huguet, A., MacNevin, R. C., McGrath, P. J., Parker, L., & MacDonald, A. J. (2011). The epidemiology of chronic pain in children and adolescents revisited: A systematic review. *Pain*, *152*(12), 2729–2738. https://doi.org/10.1016/j.pain.2011.07.016
13. MacKinnon, L. (2023). Management of fatigue in children and young people. *Paediatrics and Child Health*, *33*(10), 305–312.
14. Miro, J., Roman-Juan, J., Sanchez-Rodríguez, E., Sole, E., Castarlenas, E., & Jensen, M. P. (2023). Chronic Pain and High Impact Chronic Pain in Children and

Adolescents: A Cross-Sectional Study. *The Journal of Pain*, *24*(5), 812–823.
15. Rodrigues, V. F., Elias-Oliveira, J., Pereira, Í. S., Pereira, J. A., Barbosa, S. C., Machado, M. S. G., & Carlos, D. (2022). Akkermansia muciniphila and Gut Immune System: A Good Friendship That Attenuates Inflammatory Bowel Disease, Obesity, and Diabetes. In *Frontiers in Immunology* (Vol. 13). Frontiers Media S.A. https://doi.org/10.3389/fimmu.2022.934695
16. Rodríguez-Daza, M. C., & de Vos, W. M. (2023). Polyphenols as Drivers of a Homeostatic Gut Microecology and Immuno-Metabolic Traits of Akkermansia muciniphila: From Mouse to Man. In *International Journal of Molecular Sciences* (Vol. 24, Number 1). MDPI. https://doi.org/10.3390/ijms24010045
17. Saeed, N. K., Al-Beltagi, M., Bediwy, A. S., El-Sawaf, Y., & Toema, O. (2022). Gut microbiota in various childhood disorders: Implication and indications. In *World Journal of Gastroenterology* (Vol. 28, Number 18, pp. 1875–1901). Baishideng Publishing Group Inc. https://doi.org/10.3748/wjg.v28.i18.1875
18. Steenbruggen, T. G., Hoekstra, S. J., & Van der Gaag, E. J. (2015). Could a change in diet revitalize children who suffer from unresolved fatigue? *Nutrients*, *7*(3), 1965–1977. https://doi.org/10.3390/nu7031965
19. Subburaj, S., Thirumalaisamy, S. K., Jacob, J., & Vijayababu, P. (2026). Role of Akkermansia muciniphila in Improving Gut Health for the Prevention of Type 2 Diabetes. *Advances in Biomarker Sciences and Technology*. https://doi.org/10.1016/j.abst.2026.01.002
20. Tutelman, P. R., Langley, C. L., Chambers, C. T., Parker, J. A., Finley, G. A., Chapman, D., Jones, G. T., MacFarlane, G. J., & Marianayagam, J. (2021). Epidemiology of chronic pain in children and adolescents: A protocol for a systematic review update. *BMJ Open*, *11*(2). https://doi.org/10.1136/bmjopen-2020-043675
21. Wood JM, Sbar E. Jarisch-Herxheimer Reaction. [Updated 2025 Jul 7]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2026 Jan. https://www.ncbi.nlm.nih.gov/books/NBK557820/

How to cite this article: Anupriya Borah, Aakansha Tamhane, Saloni Kulkarni, Mugdha Pradhan. Improvement of chronic musculoskeletal pain, gastrointestinal, metabolic, and thyroid biomarkers through advanced diagnostic testing and functional nutrition in an 11-year-old female: a paediatric case report. *International Journal of Research and Review*. 2026; 13(5): 798-805. DOI: *https://doi.org/10.52403/ijrr.20260580*

******