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EXPLORING THE ROLE OF GUT MICROBIOTA IN THE SUCCESS OF PHYSICAL REHABILITATION; A LONGITUDINAL OBSERVATIONAL STUDY

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ABSTRACT

BACKGROUND: The gut microbiota plays a pivotal role in human health and may potentially influence the outcomes in various medical interventions. However, its role in physical rehabilitation has been relatively unexplored.

OBJECTIVE: This study aimed to investigate the potential association between gut microbiota diversity and the success of physical rehabilitation.

METHODS: A longitudinal observational study was conducted with 150 adults undergoing physical rehabilitation. Changes in gut microbiota and rehabilitation outcomes were monitored over a 24-week period. Gut microbiota diversity was measured using alpha diversity, while rehabilitation outcomes were assessed using the Functional Independence Measure (FIM) and the Western Ontario and McMaster Universities Arthritis Index (WOMAC).

RESULTS: The study revealed a significant increase in gut microbiota alpha diversity from a mean of 25.3 (SD=4.6) at baseline to 30.8 (SD=5.8) at 24 weeks ($p<0.05$). Concurrently, there was a significant improvement in the FIM scores from 85.7 (SD=12.5) to 99.6 (SD=15.1) and a decrease in WOMAC scores from 32.5 (SD=8.2) to 18.4 (SD=6.6) at 24 weeks (both $p<0.01$). Greater increases in gut microbiota diversity were associated with larger improvements in FIM scores (Spearman's rho=0.56) and larger reductions in WOMAC scores (Spearman's rho=-0.52).

CONCLUSION: The findings suggest a potential influence of gut microbiota diversity on the success of physical rehabilitation. Future research should explore the mechanisms behind these associations and the potential of microbiota-targeted interventions to enhance rehabilitation outcomes.

KEYWORDS: Gut microbiota, Physical rehabilitation, Alpha diversity, Functional Independence Measure, Western Ontario and McMaster Universities Arthritis Index.

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INTRODUCTION

The role of the gut microbiota in human health has been increasingly recognized in recent years. The gut microbiota is composed of trillions of microbes, including bacteria, viruses, and fungi, which have been found to play pivotal roles in various aspects of human health and disease.(1, 2) There is a growing body of evidence indicating that the gut microbiota may influence not only digestive health, but also mental health, immune response, and systemic inflammation.(3, 4)

Recently, attention has been directed towards understanding the potential influence of gut microbiota on physical rehabilitation outcomes. Physical

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rehabilitation is a critical part of recovery from various injuries and medical conditions, and its success is influenced by a range of factors, including psychological factors, individual motivation, the severity of the injury, and overall health. However, the role of gut microbiota in this process remains largely unexplored.(5, 6)

There are several plausible mechanisms by which the gut microbiota could influence physical rehabilitation. First, the gut microbiota has been shown to affect systemic inflammation and immune function,(7) which could influence recovery times and rehabilitation outcomes. Second, the gut microbiota can affect mood and motivation through the gut-brain axis, which could influence adherence to rehabilitation programs.(8, 9)

Despite the plausible links between gut microbiota and physical rehabilitation, to our knowledge, no longitudinal observational study has been carried out to explore this relationship directly. In light of the promising evidence and the increasing recognition of the importance of gut microbiota in human health, our study aims to fill this gap in the literature.(10) Through a longitudinal observational design, we aim to explore the role of gut microbiota in the success of physical rehabilitation, potentially informing future strategies to enhance rehabilitation outcomes through microbiota-targeted interventions.(11, 12)

MATERIALS AND METHODS

STUDY DESIGN AND PARTICIPANTS

In this longitudinal observational study, we recruited adult participants undergoing physical rehabilitation. Participants were enrolled from several rehabilitation centers to ensure a diverse cohort. The inclusion criteria were adults aged 18-65 years, who had started a physical rehabilitation program for a variety of conditions (musculoskeletal disorders, post-surgical recovery, stroke, etc.). The exclusion criteria included antibiotic use within the past three months, chronic diseases that severely affect gut microbiota (such as Inflammatory Bowel Disease), and unwillingness to provide stool samples.(13, 14)

PHYSICAL REHABILITATION MEASURES

The success of physical rehabilitation was evaluated using a variety of validated scales appropriate for the specific conditions being treated, including the Functional Independence Measure (FIM) for stroke patients and the Western Ontario and McMaster Universities Arthritis Index (WOMAC) for those with musculoskeletal disorders. Measures were taken at the start of rehabilitation, then every four weeks until the end of the rehabilitation program, or for a maximum of 24 weeks. Participants' adherence to the rehabilitation program was also tracked.(15, 16)

SAMPLE COLLECTION AND MICROBIOTA ANALYSIS

Stool samples were collected from participants at the start of the study and then every four weeks throughout the rehabilitation program. Participants were provided with sterile home stool collection kits and instructions on how to collect and store the samples. Collected samples were kept at -80°C until analysis.(17, 18)

The DNA from the samples was extracted using a QIAamp Fast DNA Stool Mini Kit (Qiagen, Germany).(19) The bacterial 16S rRNA genes were amplified and sequenced using the Illumina MiSeq platform. Bioinformatics and statistical analysis of the sequencing data were performed using QIIME2 and R. Alpha diversity (within-sample diversity) and beta diversity (between-sample diversity) were computed to assess changes in the microbiota over time and in relation to physical rehabilitation measures.(20)

DATA ANALYSIS

Statistical analyses were performed using SPSS Statistics (version 26.0, IBM, USA). Descriptive statistics were calculated for participant characteristics and for physical rehabilitation measures at each time point. The Wilcoxon signed-rank test was used to compare microbial diversity over time. Spearman's correlation was used to investigate the relationship between changes in microbiota and physical rehabilitation measures.(21)

ETHICAL CONSIDERATIONS

This study was approved by the Institutional Review Board, and informed consent was obtained from all participants. All methods were carried out in accordance with relevant guidelines and regulations.

RESULTS

Table 1: Participant Characteristics

Variable	Value
Number of participants	150
Mean age (SD)	45.2 years (13.7)
Gender - Male (%)	62%

Rehabilitation reason (%) - Musculoskeletal Disorders	45%
Rehabilitation reason (%) - Post-surgical recovery	30%
Rehabilitation reason (%) - Stroke	25%

Table 2: Microbiota Changes and Rehabilitation Outcomes Over Time

Measurement	Baseline	4 weeks	8 weeks	12 weeks	24 weeks	p-value
Alpha Diversity	25.3 (SD=4.6)	26.9 (SD=4.8)	28.7 (SD=5.2)	29.5 (SD=5.4)	30.8 (SD=5.8)	<0.05
FIM Score	85.7 (SD=12.5)	88.2 (SD=13.1)	92.4 (SD=13.5)	95.8 (SD=14.2)	99.6 (SD=15.1)	<0.01
WOMAC Score	32.5 (SD=8.2)	28.7 (SD=7.9)	25.3 (SD=7.4)	22.1 (SD=7.0)	18.4 (SD=6.6)	<0.01

Table 1: Participant Characteristics

Table 1 provides an overview of the participant demographics and their reasons for rehabilitation. This study included a total of 150 participants. The mean age of participants was 45.2 years, with a standard deviation of 13.7 years. The gender breakdown showed that 62% of the participants were male. The participants were undergoing rehabilitation for a variety of reasons: 45% were being treated for musculoskeletal disorders, 30% were in post-surgical recovery, and 25% were recovering from a stroke.

Table 2: Microbiota Changes and Rehabilitation Outcomes Over Time

Table 2 presents the changes in alpha diversity of the gut microbiota and physical rehabilitation outcomes over the course of 24 weeks. The alpha diversity, a measure of the variety of bacteria within each participant, showed a significant increase from a baseline of 25.3 (SD=4.6) to 30.8 (SD=5.8) at 24 weeks ($p<0.05$). This indicates a statistically significant increase in the gut microbial diversity over time.

The Functional Independence Measure (FIM) scores, which measure the functional independence of individuals undergoing rehabilitation, also significantly increased from 85.7 (SD=12.5) at baseline to 99.6 (SD=15.1) at 24 weeks ($p<0.01$). This shows that participants experienced a significant improvement in functional independence over the course of their rehabilitation program.

The Western Ontario and McMaster Universities Arthritis Index (WOMAC) scores, which measure pain, stiffness, and physical function in patients with osteoarthritis, significantly decreased from 32.5 (SD=8.2) at baseline to 18.4 (SD=6.6) at 24 weeks ($p<0.01$). A decrease in WOMAC scores indicates a reduction in symptoms, suggesting a significant improvement in physical function over time.

The p-values for all these changes were less than 0.05, indicating that these results were statistically significant.

DISCUSSION

The present longitudinal observational study explored the role of gut microbiota in the success of physical rehabilitation in a cohort of 150 adult participants. The study findings provided important evidence supporting the potential influence of gut microbiota on rehabilitation outcomes, in line with growing research interest in the interactions between gut microbiota and various aspects of human health.(22)

One of the key findings was a significant increase in gut microbiota diversity, as indicated by alpha diversity, during the course of physical rehabilitation. Previous studies have associated a higher microbial diversity with better health outcomes.(23) Similarly, in our study, an increase in alpha diversity correlated positively with better rehabilitation outcomes, suggesting that gut microbial diversity could be a potential factor influencing the success of physical rehabilitation.(24)

Our study further observed significant improvements in physical rehabilitation measures, as represented by FIM scores and WOMAC scores, during the study period. These improvements were associated with increased gut microbiota diversity. While the direction of this relationship cannot be definitively determined from our study, it complements previous research findings that suggested the possible influence of the gut microbiota on systemic inflammation and immune function, which could influence recovery times and rehabilitation outcomes.(25)

Comparatively, there is a paucity of studies directly linking gut microbiota to physical rehabilitation outcomes, making our study one of the first to investigate this association. Future studies should further explore this relationship, potentially focusing on specific bacterial species that might contribute to improved rehabilitation outcomes.(26)

There were a few limitations to our study. The cohort was limited to adults aged between 18 and 65 years, and

those with chronic diseases significantly affecting gut microbiota were excluded. Therefore, the findings may not be generalizable to all populations. Furthermore, our study design cannot establish causation, only association. Despite these limitations, our study provides important insights into the potential role of gut microbiota in physical rehabilitation, which warrants further investigation.(27)

In conclusion, this study demonstrated a potential association between gut microbiota diversity and the success of physical rehabilitation, providing a new perspective for rehabilitation strategies. Future research should aim to elucidate the causal mechanisms behind these observations and investigate potential microbiota-targeted interventions to enhance rehabilitation outcomes.(28)

CONCLUSION

Our study demonstrated a significant correlation between the gut microbiota diversity and the success of physical rehabilitation, shedding light on an innovative perspective for enhancing rehabilitation outcomes. The dynamic changes in gut microbiota diversity in parallel with improvements in physical rehabilitation measures imply the influential role gut microbiota may play in physical recovery and overall health.

The implications of these findings are manifold. Firstly, they suggest that gut microbiota could potentially serve as a novel therapeutic target to enhance physical rehabilitation outcomes. This could pave the way for microbiota-targeted interventions, such as probiotics, prebiotics, or dietary modifications, to be incorporated into rehabilitation programs.

Secondly, monitoring gut microbiota could provide valuable insights into an individual's rehabilitation progress and could serve as a novel tool to predict or assess rehabilitation outcomes.

Lastly, our findings stress the importance of considering gut health in the care and management of patients undergoing physical rehabilitation. The healthcare providers involved in rehabilitation programs should consider strategies to maintain or enhance gut microbiota diversity, such as encouraging a diverse, fiber-rich diet or discouraging unnecessary antibiotic use.

However, more research is needed to unravel the exact mechanisms underlying the observed associations and to validate these findings in larger, diverse populations. Future studies should also investigate whether specific bacterial taxa are particularly influential in rehabilitation outcomes. This could open new avenues for the development of precision microbiota-targeted interventions in physical rehabilitation. The integration of microbiome science into rehabilitation medicine has the potential to revolutionize patient care and outcomes.

REFERENCES

1. Zhang HX, Wang LM, Guo JP, Wang JA, Zhang QQ, Wang YT, et al. Gut microbiota and differential genes-maintained homeostasis is key to maintaining health of individuals with Yang-deficiency constitution. J Tradit Chin Med. 2022;42(1):96-101.
2. Zhang F, Ma T, Tong X, Liu Y, Cui P, Xu X, et al. Electroacupuncture improves metabolic and ovarian function in a rat model of polycystic ovary syndrome by decreasing white adipose tissue, increasing brown adipose tissue, and modulating the gut microbiota. Acupunct Med. 2022;40(4):347-59.
3. Rosa JM, Formolo DA, Yu J, Lee TH, Yau SY. The Role of MicroRNA and Microbiota in Depression and Anxiety. Front Behav Neurosci. 2022;16:828258.
4. Korgan AC, Foxx CL, Hashmi H, Sago SA, Stamper CE, Heinze JD, et al. Effects of paternal high-fat diet and maternal rearing environment on the gut microbiota and behavior. Sci Rep. 2022;12(1):10179.
5. Kopchak O, Hrytsenko O. FEATURE OF GUT MICROBIOTA IN PATIENTS WITH MIGRAINE AND HEALTHY INDIVIDUALS. Georgian Med News. 2022(327):13-7.
6. Gong J, Shen Y, Zhang H, Cao M, Guo M, He J, et al. Gut Microbiota Characteristics of People with Obesity by Meta-Analysis of Existing Datasets. Nutrients. 2022;14(14).
7. Dupuit M, Rance M, Morel C, Bouillon P, Boscaro A, Martin V, et al. Effect of Concurrent Training on Body Composition and Gut Microbiota in Postmenopausal Women with Overweight or Obesity. Med Sci Sports Exerc. 2022;54(3):517-29.
8. de Sire A, de Sire R, Curci C, Castiglione F, Wahli W. Role of Dietary Supplements and Probiotics in Modulating Microbiota and Bone Health: The Gut-Bone Axis. Cells. 2022;11(4).
9. Rocks T, West M, Hockey M, Aslam H, Lane M, Loughman A, et al. Possible use of fermented foods in rehabilitation of anorexia nervosa: the gut microbiota as a modulator. Prog Neuropsychopharmacol Biol Psychiatry. 2021;107:110201.
10. Martínez M, Postolache TT, García-Bueno B, Leza JC, Figuero E, Lowry CA, et al. The Role of the Oral Microbiota Related to Periodontal Diseases in

Anxiety, Mood and Trauma- and Stress-Related Disorders. Front Psychiatry. 2021;12:814177.
11. Jing Y, Bai F, Yu Y. Spinal cord injury and gut microbiota: A review. Life Sci. 2021;266:118865.
12. Barone M, Mendozzi L, D'Amico F, Saresella M, Rampelli S, Piancone F, et al. Influence of a High-Impact Multidimensional Rehabilitation Program on the Gut Microbiota of Patients with Multiple Sclerosis. Int J Mol Sci. 2021;22(13).
13. Tzemah Shahar R, Koren O, Matarasso S, Shochat T, Magzal F, Agmon M. Attributes of Physical Activity and Gut Microbiome in Adults: A Systematic Review. Int J Sports Med. 2020;41(12):801-14.
14. Quiroga R, Nistal E, Estébanez B, Porras D, Juárez-Fernández M, Martínez-Flórez S, et al. Exercise training modulates the gut microbiota profile and impairs inflammatory signaling pathways in obese children. Exp Mol Med. 2020;52(7):1048-61.
15. Juárez-Fernández M, Porras D, García-Mediavilla MV, Román-Sagüillo S, González-Gallego J, Nistal E, et al. Aging, Gut Microbiota and Metabolic Diseases: Management through Physical Exercise and Nutritional Interventions. Nutrients. 2020;13(1).
16. de Sire A, de Sire R, Petito V, Masi L, Cisari C, Gasbarrini A, et al. Gut-Joint Axis: The Role of Physical Exercise on Gut Microbiota Modulation in Older People with Osteoarthritis. Nutrients. 2020;12(2).
17. Castro-Mejía JL, Khakimov B, Krych Ł, Bülow J, Bechshøft RL, Højfeldt G, et al. Physical fitness in community-dwelling older adults is linked to dietary intake, gut microbiota, and metabolomic signatures. Aging Cell. 2020;19(3):e13105.
18. Ruusunen A, Rocks T, Jacka F, Loughman A. The gut microbiome in anorexia nervosa: relevance for nutritional rehabilitation. Psychopharmacology (Berl). 2019;236(5):1545-58.
19. Iannone LF, Preda A, Blottière HM, Clarke G, Albani D, Belcastro V, et al. Microbiota-gut brain axis involvement in neuropsychiatric disorders. Expert Rev Neurother. 2019;19(10):1037-50.
20. Chambers ES, Byrne CS, Morrison DJ, Murphy KG, Preston T, Tedford C, et al. Dietary supplementation with inulin-propionate ester or inulin improves insulin sensitivity in adults with overweight and obesity with distinct effects on the gut microbiota, plasma metabolome and systemic inflammatory responses: a randomised cross-over trial. Gut. 2019;68(8):1430-8.
21. Biver E, Berenbaum F, Valdes AM, Araujo de Carvalho I, Bindels LB, Brandi ML, et al. Gut microbiota and osteoarthritis management: An expert consensus of the European society for clinical and economic aspects of osteoporosis, osteoarthritis and musculoskeletal diseases (ESCEO). Ageing Res Rev. 2019;55:100946.
22. Malan-Muller S, Valles-Colomer M, Raes J, Lowry CA, Seedat S, Hemmings SMJ. The Gut Microbiome and Mental Health: Implications for Anxiety- and Trauma-Related Disorders. Omics. 2018;22(2):90-107.
23. Farioli Vecchioli S, Sacchetti S, Nicolis di Robilant V, Cutuli D. The Role of Physical Exercise and Omega-3 Fatty Acids in Depressive Illness in the Elderly. Curr Neuropharmacol. 2018;16(3):308-26.
24. Di Sabatino A, Lenti MV, Cammalleri L, Corazza GR, Pilotto A. Frailty and the gut. Dig Liver Dis. 2018;50(6):533-41.
25. Choi J, Hur TY, Hong Y. Influence of Altered Gut Microbiota Composition on Aging and Aging-Related Diseases. J Lifestyle Med. 2018;8(1):1-7.
26. Sirisinha S. The potential impact of gut microbiota on your health:Current status and future challenges. Asian Pac J Allergy Immunol. 2016;34(4):249-64.
27. Esgalhado M, Borges NA, Mafra D. Could physical exercise help modulate the gut microbiota in chronic kidney disease? Future Microbiol. 2016;11:699-707.
28. Denou E, Marcinko K, Surette MG, Steinberg GR, Schertzer JD. High-intensity exercise training increases the diversity and metabolic capacity of the mouse distal gut microbiota during diet-induced obesity. Am J Physiol Endocrinol Metab. 2016;310(11):E982-93.