Patient Preference and Adherence

Dovepress
open access to scientific and medical research

Open Access Full Text Article

REVIEW

Preferences and Adherence of People with Prediabetes for Disease Management and Treatment: A Systematic Review

Zonghao Ren, Xianpeng Xu, Rensong Yue

Department of Endocrinology, Hospital of Chengdu University of Traditional Chinese Medicine, Chengdu, People's Republic of China

Correspondence: Rensong Yue, Email songrenyue@cdutcm.edu.cn

Objective: To comprehensively summarize the evaluation, preference, and expectations of people with prediabetes regarding the management and treatment of pre-diabetes.

Methods: Search PubMed, Embase, Web of Science, Cochrane Library and CNKI for articles about prediabetes, preferences, and expectations from inception of the database to June 2023.

Results: A total of 18 studies involving 17,240 participants with prediabetes were included. Although the preferences and views of people with prediabetes vary widely, there are certain trends: 1) Compared with drug therapy, people with prediabetes prefer exercise and nutrition therapies. 2) People with prediabetes expect intensive lifestyle interventions guided by professionals. 3) Effective communication between doctors and people with prediabetes is crucial for promoting the development and implementation of treatment plans.

Conclusion: The results of this systematic review showed that people with prediabetes prefer intensive lifestyle interventions due to concerns about drug side effects, dependency, and other factors. In addition, drug acceptance and lifestyle interventions options differed among different populations, which emphasized the significance of individualized therapy.

Keywords: prediabetes, patient preferences, prediabetes management, systematic review

Introduction

Impaired Fasting Glucose (IFG) is defined as a fasting blood glucose of 5.6 to 6.9 mmol/L. Impaired Glucose Tolerance (IGT) is defined as a fasting blood glucose of less than 5.6 mmol/L and a plasma glucose level of 7.8–11.0 mmol/L at 2 hours after OGTT or a glycated hemoglobin of 5.7%-6.4%. Prediabetes is the stage between normal glucose metabolism and diabetes mellitus and is primarily characterized by impaired fasting glucose, impaired glucose tolerance, or both.[1,2] Currently, the prevalence of prediabetes is rapidly increasing worldwide. The world map of diabetes published by IDF in 2021 shows that about 541 million people are in the stage of impaired glucose tolerance.[3] The prediabetes pandemic will greatly affect the prevalence of diabetes and its complications, and has gradually become a major public health problem.

Currently, the diagnostic criteria for prediabetes are not yet uniform, but the associated risks, such as glucose metabolism disorders, lipid metabolism disorders, and cardiovascular and cerebrovascular risks, are well-established.[4] Some studies have found that about 10% to 15% of people with prediabetes will develop to dominant diabetes each year without intervention, and up to 79% of people with prediabetes will eventually progress to diabetes.[5,6]

Current interventions for prediabetes primarily consist of behavioral management and pharmacological interventions, specifically metformin,[7] which poses a major challenge to patient compliance. With the development of evidence-based medicine, patient preferences and evaluations have become increasingly important, and healthcare professionals have also realized the importance of personalized treatment.[8] They are increasingly incorporating patient perspectives into treatment decisions, recognizing that patients' unique environments, goals, and values should be referenced along with clinical evidence.[9] But patients' preferences and values are diverse and may differ from medical guidelines. Therefore,

Received: 26 August 2023
Accepted: 8 November 2023
Published: 15 November 2023

identifying the preferences and expectations of the prediabetic population regarding screening and intervention methods is beneficial for clinicians in developing effective diagnostic and treatment plans. In this study, the evidence on prediabetes population preferences was systematically collected.

Methods

Eligibility Criteria

This study includes literature that meets the following criteria:1) The study population is people with prediabetes; 2) Research content relates to participants' views, preferences, and expectations regarding the management and treatment of prediabetes; 3) The research content includes the factors that influence the treatment of people with prediabetes. The exclusion criteria are as follows: 1) Not related to views, preferences and expectations of people with prediabetes; 2) Letters, reviews, case reports, invent and posters.

Data Sources and Retrieval Strategies

Search for publications in 5 databases, PubMed, Embase, Web of Science, Cochrane Library, China National Knowledge Internet (CNKI). Search time from the establishment of the database to June 2023. Using PubMed as an example, we searched the PubMed database for mesh terms related to prediabetes and patient preferences and applied keyword searching in combination with title summarization to find more comprehensive literature. Key phrases such as "prediabetes" and "prediabetic states" were used in conjunction with terms like "patient preferences", "patient compliance", or "patient values", among others. Table 1 shows the PubMed search strategy. When searched other databases, we adjusted the retrieval strategy accordingly.

Data Extraction and Quality Evaluation

Two authors independently reviewed retrieved studies using inclusion and exclusion criteria, read the title and abstract for initial screening, and communicated with the corresponding author to clarify any discrepancies. The reviewers extracted the first author, publication date, research type, research design, sample size, statistical methods, and research findings. Two reviewers independently use Agency for Healthcare Research and Quality (AHRQ),[10] and communicated with the corresponding author when encountered differences of opinion. The AHRQ scale is a commonly used observational study assessment tool. Research is rated by answering 11 questions with "Yes" (1 point), "No" (0 point), and "Uncertain" (0 point). It is divided into three levels: low quality 0–3 points, medium quality 4–7 points, and high quality 8–11 points. Figure 1 shows the systematic literature review process.

Table 1 Search Strategy for PubMed

Query	Search Term
1	Prediabetes [MeSH]
2	Prediabetic States[Title/Abstract] OR State, Prediabetic[Title/Abstract] OR States, Prediabetic [Title/Abstract] OR Prediabetes[Title/Abstract]
3	1 OR 2
4	Patient preference [MeSH]
5	Patient preference[Title/Abstract] OR Patient Preferences[Title/Abstract] OR (Preference, Patient[Title/Abstract] OR (patient compliance[Title/Abstract] OR (patient decision[Title/Abstract] OR (patient expectation[Title/Abstract] OR (Patient Value[Title/Abstract] OR (patient view[Title/Abstract])
6	4 OR 5
7	3 AND 6

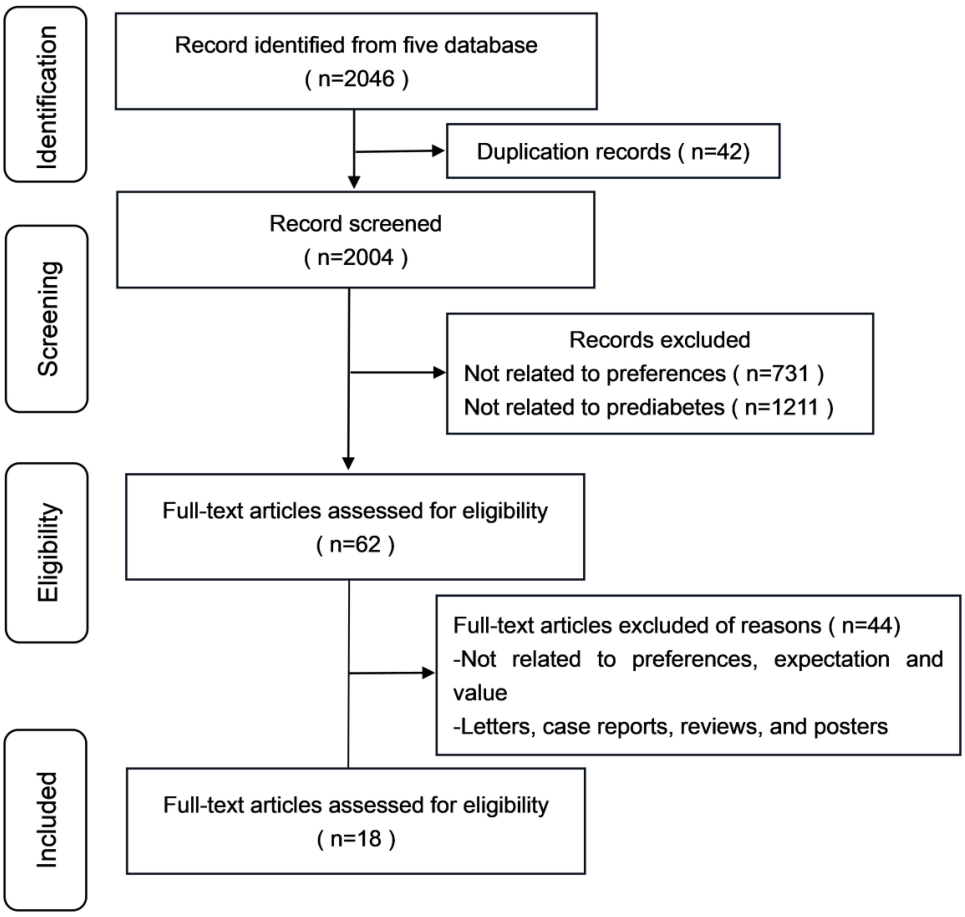

Figure 1 Flow diagram of the selection process.

Results

Characteristics of Included Studies

A total of 2017 articles were retrieved from the five databases. After deduplication and screening the titles and abstracts, 62 articles were selected for full-text retrieval. Finally, 18 articles were found that met the inclusion criteria. Research on preferences of people with prediabetes is mainly conducted in the United States (n=12), China (n=3), Poland (n=1), Canada (n=1), and Australia (n=1). Table 2 provides an overview of 18 studies, including study data, sample size, study design, study description, patient preferences or wishes.

The Preferences and Expectations for Medical Treatment

There are 6 studies on drug therapy preferences and expectations. After summarizing the results of six studies, it was concluded that people with prediabetes commonly exhibit psychological resistance to drug treatment such as metformin. When there are other treatment options, they usually do not take drug treatment as their first choice, which may be related to the fear of drug side effects and drug dependence. However, people with a family history of diabetes or a willingness to lose weight have a higher acceptance of metformin. Bandi et al created a decision support manual for people with prediabetes.[11] They found that Spanish speakers and people with low levels of education were more willing to accept externally given suggestions for disease management and showed higher acceptance of metformin use. Moin et al included 515 participants in their study. 121 (23.5%) of the participants were willing to take metformin. Acceptance was higher in those under 50 years of age than in those over 60 years of age. Participants indicated that they would be willing to take the drug if it could help with treatment, even if there were side effects.[19] Participants in the O'Brien et al study were very grateful to receive knowledge about prediabetes and diabetes during the research interview. When they learned

Table 2 Characteristics of Included Studies and Summary of Results

Author	Country	Date	Study Design	Sample Size	Study Description	Preferences, Expectations, and Values	Score
Bandi et al[11]	America	2021	Cross-sectional	40	Questionnaire and a face-to-face Interview	Spanish-speaking individuals and those with lower educational attainment exhibited a greater propensity to employ lifestyle modifications, dietary adjustments and exercise in order to effectively address prediabetes.	7
Chen et al[12]	China	2020	Cross-sectional	1241	Questionnaire and one-on-one online interview	The overwhelming majority of individuals with glycemic disturbances (96%) evinced a predilection for active participation in virtual diabetes health forums.	8
Coles et al[13]	Australia	2014	Randomized clinical trial	144	Randomly allocated to three dietary groups	Compared to men, women were more likely to follow a fixed diet during weight loss	8
Dyer et al[14]	America	2020	Cross-sectional	119	Face-to-face or online semi-structured interviews	Women like to communicate face-to-face with same-sex people about life management issues	9
Epstein et al[15]	America	2020	Cross-sectional	4	Multiple baseline design	Episodic future thinking improve patient adherence to therapy	8
Fisher et al[16]	America	2020	Cross-sectional	33	Audio-recorded, semi-structured interviews	When families faced the threat of diabetes, mothers usually took a more central position in usual health management.	9
Holmes[17]	America	2022	Prospective study	10	Observation of changes in physical indicators after a sports intervention	Patients hoped to be encouraged and guided when performing an exercise intervention.	7
Marcinkiewicz et al[18]	Poland	2018	Cross-sectional	316	Questionnaire and laboratory determinations	Prophylactic regular compulsory examinations improve patient adherence	8
Moin et al[19]	America	2021	Cross-sectional	515	Teleconference and face-to-face interviews	The majority of patients tended to use non-drug therapy	8
O'Brien et al[20]	America	2016	Cross-sectional	35	Semi-structured interviews	Most patients felt that intensive life intervention and metformin were acceptable, although they would prefer intensive life intervention.	9
Rhodes at al[21]	America	2011	Cross-sectional	70	Face-to-face interviews	Most adolescents and their parents rated T2DM without complications treated with diet as most desirable	9

(*Continued*)

Table 2 (Continued).

Author	Country	Date	Study Design	Sample Size	Study Description	Preferences, Expectations, and Values	Score
Rony et al[22]	America	2022	Cross-sectional	52	Structured interviews	Patients preferred to adopt non-pharmaceutical approaches for improving their glycemic control	9
Speaker et al[23]	America	2021	Retrospective cohort study	9526	Extracting data from electronic medical records in primary care clinics	Younger age, higher BMI, and female sex were positively associated with the acceptance of metformin or medical nutrition therapy.	10
Strauss et al[24]	America	2015	Cross-sectional	372	Questionnaire	Most patients believe that only overt diabetes have a significant impact on their lives, even though they know they have no prediabetes symptoms.	8
Taylor et al[25]	Canada	2015	Cross-sectional	232	Questionnaire	86% of respondents expressed interest in physical activity in prediabetes.	8
Valero-Elizondo et al[26]	America	2019	Cross-sectional	4186	Extracting data from the National Health Interview Survey (NHIS)	Prediabetics at cardiovascular risk were more likely to accept lifestyle changes.	7
Al et al[27]	China	2019	Randomized clinical trial	60	Questionnaire and Determination of glucose metabolism index	Patients who kept the APP -based food diary had better control over their diet and their own behaviour.	7
DUAN et al[28]	China	2017	Cross-sectional	285	Semi-structured interviews and Determination of glucose metabolism index	In older and non-working patients, they were more likely to implement automatic behavioral management of prediabetes.	7

that treatment with metformin could be beneficial, they expressed more confidence in managing prediabetes. Participants indicated they would be willing to try metformin if they wanted to lose more weight.[20] Rhodes et al studied 70 adolescents with prediabetes and their families, and the results showed that adolescents with a family history of diabetes had a higher acceptance of oral medications and insulin.[21] The study by Rony et al shows that participants prefer nonpharmacologic therapy and suggests that participants' low medication adherence may be related to medication side effects, fear of medication dependence, and distrust of the health care system. People with prediabetes want to be respected by health care providers, especially the black community.[22] Speaker et al found that women, young people, and people with high BMI paid more attention to prediabetes intervention, white people preferred metformin, and black people preferred MNT.[23]

The Preferences and Expectations for Personal Behavior Management

Ten studies reported on participants' attitudes toward personal behavior management. After summarizing the ten studies, it was found that people' attitudes toward prediabetes intervention through exercise and lifestyle change were positive, mainly because the body and mind could benefit more. And by teaching external factors such as professionals and mobile apps, participants' blood glucose control and behavioral adherence could be effectively improved.

Coles' randomized parallel intervention suggested that male participants with prediabetes preferred weight loss training under the guidance of professionals and preferred animal protein diet. While women have better self-control

and show higher compliance in diet without choice.[13] Among the individuals who participated in Moin et al's study, 70% stated that they were more inclined to accept ILI (intensive lifestyle intervention) than metformin, and the proportion of women choosing ILI was significantly higher than that of men, and the participants with high BMI were also more willing to accept ILI.[19] Study participants by O'Brien et al indicated that they preferred ILI as their preferred treatment because they believed it was a natural treatment with fewer side effects and other benefits besides reducing the risk of diabetes.[20] Fisher et al have shown that mothers in general would take a more proactive and empowering role in family-centered diabetes self-management education (DSME).[16] Holmes et al found that adolescents with prediabetes enjoy resistance training (RET) at home and effectively improve their insulin resistance under the guidance of professionals.[17] Marcinkiewicz et al found that workers followed medical advice 100% of the time after the fasting blood glucose test was included in mandatory employee screening.[18] Previous studies had shown that these data were merely 36% to 93%, which will be useful for screening prediabetes.[29] Taylor et al reported that respondents wanted to acquire knowledge about PA (physical activity) (75%) and were willing to participate in PA (96%). They were more interested in regular and varied moderate-intensity exercise, such as walking.[25] Valero Elizondo et al found that older participants (≥ 65 years) generally did not accept more than two lifestyle interventions, whereas women and low-income groups generally received the least external health management advice.[26] The study of AI et al confirmed that participants are willing to actively control their daily caloric intake. With the assistance of the mobile application, participants were capable of adhering to diet healthily, manage exercise, monitor blood glucose, and gain confidence in overcoming the disease.[27] Duan et al found that age and freelance work were independent factors that improved compliance in people with prediabetes. They also discovered that using pictures, videos, and other means to prompt participants through cell phones, the Internet, and other platforms was more effective in enhancing participant satisfaction.[28]

Additional Perspectives on Preferences and Expectations

Chen et al utilized "self-efficacy" as the dependent variable in their study, conducting a logistic regression analysis on the prediabetes population. The results indicated that individuals with high self-efficacy were more likely to be urban residents, married, and inclined towards interpersonal communication. In addition, the researchers found that fewer than 12% of respondents used suggestions from healthcare professionals as a source of disease information. It was also discovered that 72% of participants preferred to obtain disease information through search engines and social media, particularly young people. Most respondents reported feeling more confident in managing their illnesses after participating in online health communities.[12] The women who participated in the study by Dyer et al preferred to share their thoughts and information about illness face-to-face with individuals of the same sex. The face-to-face form of sharing makes individuals feel less lonely, while sharing exclusively with women gives them more confidence in communicating with one another.[14] According to the research findings of Epstein et al, training participants to learn episodic future thinking may help improve treatment adherence. This improvement may be attributed to participants placing greater emphasis on the long-term benefits of treatment.[15] The study by Marcinkiewicz et al also suggests that people with prediabetes may avoid glycemic control for economic reasons, as they fear that the disease could result in job loss.[18] From the study by Rhodes et al, 72% of adolescents and 100% of parents believe that controlling diabetes through diet alone, without complications, is the most ideal state for the future. In addition, most participants believe that end-stage renal disease is the most feared complication.[21] Although participants in Strauss et al's research are in the early stages of diabetes, most of them believe they have no symptoms of diabetes and that it will not have an impact on their lives.[24]

Discussion

This systematic literature review includes 18 publications summarizing the preferences, values, and expectations of people with prediabetes regarding drug treatment and personal behavior management. As a precursor to diabetes, prediabetes is associated with an increased risk of developing diabetes, cardiovascular events, and mortality.[30] Given this chronic condition of prediabetes, it is crucial to understand the treatment preferences and expectations of people with prediabetes, as this could help clinicians weigh the advantages and disadvantages of various treatment regimens and assist clinicians to provide accurate individualized treatment for people with prediabetes, which would improve patients' sense of involvement and compliance. Drug treatment is the most crucial aspect of intervention measures in early

diabetes. However, it is evident that people with prediabetes tend to have a negative and wait-and-see approach when it comes to drug intervention, specifically with metformin. Although metformin has been associated with lactic acidosis, gastrointestinal discomfort, anorexia, and other adverse effects.[31,32] However, current evidence supports the efficacy of metformin in reducing blood glucose levels, improving insulin resistance, and promoting weight loss in the early treatment of diabetes.[33] It is therefore necessary for clinicians to consider methods to improve the acceptance of drug treatment.

Diet and exercise management must not be ignored in the treatment of prediabetes. Reducing carbohydrate intake, consuming low-glycemic index (GI) foods, having regular meals, and engaging in physical activity are effective measures that can prevent the worsening of the disease.[34] In this study, it was found that people with prediabetes are generally willing to manage their blood glucose levels through dietary changes and physical activity. This willingness stems from their own efforts to attain a sense of accomplishment. However, the current issue is that prediabetic individuals have a limited understanding of lifestyle changes. In addition, various groups may hold different perspectives and preferences regarding lifestyle changes, which can be influenced by factors such as age, gender, income, and so on. Therefore, healthcare providers need to develop personalized treatment plans for various groups. In addition to real-world interventions, the internal world of prediabetes people also deserves attention. According to this study, people with prediabetes experience feelings of loneliness, confusion, anxiety, and other psychological conditions. Establishing appropriate communication channels for various groups and promoting two-way communication will help enhance low mood of people with prediabetes and increase their knowledge about prediabetes, diabetes, and its various complications. Consequently, addressing the issue of providing more attention and patience to prediabetic people is something that medical providers need to focus on.

Limitations

The research is a qualitative retrospective analysis and has limitations. Firstly, there is a shortage of literature amount that meets the inclusion criteria, and some of the included literatures have unclear preferences and expectations of people with prediabetes, which could impact the final results. Secondly, there is insufficient accurate and standardized information to define patient preferences, expectations, and values. The method used to review the literature and summarize the findings is tentative and empirical, so the results may vary.

Conclusion

In summary, this systematic review shows that drug therapy is typically not the initial option for people with prediabetes. Instead, they prefer to prevent and manage the disease by making lifestyle changes. Prediabetic people hope to receive comprehensive counseling from professionals in their battle against disease. Gender, age, work and other factors affect the choice of treatment for the people with prediabetes.

Funding

This research was funded by Science and Technology Research Special Project of Sichuan Provincial Department (2022YFS0382).

Disclosure

The authors report no conflicts of interest in this work.

References

1. Diabetes Care. Classification and diagnosis of diabetes: standards of medical care in diabetes-2020. *Diabetes Care*. 2020;43(Suppl 1):S14–S31. doi:10.2337/dc20-S002
2. Buysschaert M, Bergman M. Definition of prediabetes. *Med Clin North Am*. 2011;95(2):289–vii. doi:10.1016/j.mcna.2010.11.002
3. Magliano DJ, Boyko EJ. Committee Idf Dates; *IDF Diabetes Atlas*. Brussels: International Diabetes Federation; 2021.
4. Blond MB, Færch K, Herder C, et al. The prediabetes conundrum: striking the balance between risk and resources. *Diabetologia*. 2023;66(6):1016–1023. doi:10.1007/s00125-023-05890-y

5. Richter B, Hemmingsen B, Metzendorf MI, et al. Development of type 2 diabetes mellitus in people with intermediate hyperglycaemia. *Cochrane Database Syst Rev*. 2018;10(10):Cd012661. doi:10.1002/14651858.CD012661.pub2
6. Lee CMY, Colagiuri S, Woodward M, et al. Comparing different definitions of prediabetes with subsequent risk of diabetes: an individual participant data meta-analysis involving 76 513 individuals and 8208 cases of incident diabetes. *BMJ Open Diabetes Res Care*. 2019;7(1):e000794. doi:10.1136/bmjdrc-2019-000794
7. Tseng E, Lam K, Meza K, et al. Lower-intensity interventions for prediabetes: a systematic review. *Am J Prev Med*. 2023;65(5):906–915. doi:10.1016/j.amepre.2023.05.012
8. Swift JK, Mullins RH, Penix EA, et al. The importance of listening to patient preferences when making mental health care decisions. *World Psychiatry*. 2021;20(3):316–317. doi:10.1002/wps.20912
9. Montori VM, Brito JP, Murad MH. The optimal practice of evidence-based medicine: incorporating patient preferences in practice guidelines. *JAMA*. 2013;310(23):2503–2504. doi:10.1001/jama.2013.281422
10. Stang A. Critical evaluation of the Newcastle-Ottawa scale for the assessment of the quality of nonrandomized studies in meta-analyses. *Eur J Epidemiol*. 2010;25(9):603–605. doi:10.1007/s10654-010-9491-z
11. Bandi K, Vargas MC, Lopez A, et al. Development and evaluation of a prediabetes decision aid in primary care: examining patient-reported outcomes by language preference and educational attainment. *The Science of Diabetes Self-Management and Care*. 2021;47(3):216–227. doi:10.1177/26350106211009189
12. Chen ZH, Zhang CC, Fan GH. Interrelationship between interpersonal interaction intensity and health self-efficacy in people with diabetes or prediabetes on online diabetes social platforms: an In-Depth Survey in China. *Int J Environ Res Public Health*. 2020;17(15). doi:10.3390/ijerph17155375
13. Coles LT, Fletcher EA, Galbraith CE, et al. Patient freedom to choose a weight loss diet in the treatment of overweight and obesity: a randomized dietary intervention in type 2 diabetes and pre-diabetes. *Int J Behav Nutr Phys Act*. 2014;11(1):64. doi:10.1186/1479-5868-11-64
14. Dyer KE, Moreau JL, Finley E, et al. Tailoring an evidence-based lifestyle intervention to meet the needs of women Veterans with prediabetes. *Women Health*. 2020;60(7):748–762. doi:10.1080/03630242.2019.1710892
15. Epstein LH, Jimenez-Knight T, Honan AM, et al. Imagine to remember: an episodic future thinking intervention to improve medication adherence in patients with type 2 diabetes. *Patient Prefer Adherence*. 2022;16:95–104. doi:10.2147/PPA.S342118
16. Fisher CL, Mullis MD, Lee D, et al. Family communication central to mothers' type 2 diabetes self-management. *Fam Syst Health*. 2020;38(4):396–405. doi:10.1037/fsh0000550
17. Holmes CJ, Racette SB, Symonds L, et al. Feasibility and efficacy of telehealth-based resistance exercise training in adolescents with cystic fibrosis and glucose intolerance. *Int J Environ Res Public Health*. 2022;19(6):3297. doi:10.3390/ijerph19063297
18. Marcinkiewicz A, Hanke W, Kaluzny P, et al. Can periodical examinations of employees be useful in detection of glycaemia impairment and improving patients' adherence to medical recommendations? *Int J Environ Res Public Health*. 2018;15(4):638. doi:10.3390/ijerph15040638
19. Moin T, Martin JM, Mangione CM, et al. Choice of intensive lifestyle change and/or metformin after shared decision making for diabetes prevention: results from the Prediabetes Informed Decisions and Education (PRIDE) Study. *Med Decis Making*. 2021;41(5):607–613. doi:10.1177/0272989X211001279
20. O'brien MJ, Moran MR, Tang JW, et al. Patient perceptions about prediabetes and preferences for diabetes prevention. *Diabetes Educ*. 2016;42(6):667–677. doi:10.1177/0145721716666678
21. Rhodes ET, Prosser LA, Lieu TA, et al. Preferences for type 2 diabetes health states among adolescents with or at risk of type 2 diabetes mellitus. *Pediatr Diabetes*. 2011;12(8):724–732. doi:10.1111/j.1399-5448.2011.00772.x
22. Rony M, Quintero-Arias C, Osorio M, et al. Perceptions of the healthcare system among black men with previously undiagnosed diabetes and prediabetes. *J Racial Ethnic Health Disparit*. 2022. doi:10.1007/s40615-022-01488-z
23. Spraker SL, Rastogi R, Sussman TA, et al. Treatment of patients with prediabetes in a primary care setting 2011–2018: an observational study. *J Gen Intern Med*. 2021;36(4):923–929. doi:10.1007/s11606-020-06354-4
24. Strauss SM, Rosedale MT, Kaur N. Illness perceptions among adults at risk for diabetes. *Diabetes Educ*. 2015;41(2):195–202. doi:10.1177/0145721715569003
25. Taylor LM, Spence JC, Raine K, et al. Self-reported physical activity preferences in individuals with prediabetes. *Physician Sportsmed*. 2011;39(2):41–49. doi:10.3810/psm.2011.05.1894
26. Valero-Elizondo J, Aneni EC, Osondu CU, et al. Gaps in provider lifestyle counseling and its adherence among obese adults with prediabetes and diabetes in the United States. *Prev Med*. 2019;129:105815. doi:10.1016/j.ypmed.2019.105815
27. Ai M, Sun WW, Ding Q, et al. Effects of app-based diet diary on the diet control of prediabetes patients with impaired glucose tolerance. *Nurs J Chin PLA*. 2019;36(11):27–30. doi:10.3969/j.issn.1008-9993.2019.11.007
28. Duan MX, Mo ML, Wang TW, et al. Compliance and influencing factors of health behavior intervention among community people with prediabetes. *J Third Milit Med Univ*. 2017;39(13):1404–1409. doi:10.16016/j.1000-5404.201703143
29. Garcia-Pérrz LE, Alvarez M, Dilla T, et al. Adherence to therapies in patients with type 2 diabetes. *Diabetes Ther*. 2013;4(2):175–194. doi:10.1007/s13300-013-0034-y
30. Echouffo-Tcheugui JB, Perreault L, Ji L, et al. Diagnosis and management of prediabetes: a review. *JAMA*. 2023;329(14):1206–1216. doi:10.1001/jama.2023.4063
31. Boucaud-Maitre D, Ropers J, Porokhov B, et al. Lactic acidosis: relationship between metformin levels, lactate concentration and mortality. *Diabetic Med*. 2016;33(11):1536–1543. doi:10.1111/dme.13098
32. Mccreight LJ, Bailey CJ, Pearson ER. Metformin and the gastrointestinal tract. *Diabetologia*. 2016;59(3):426–435. doi:10.1007/s00125-015-3844-9
33. Hostalek U, Gwilt M, Hildemann S. Therapeutic use of metformin in prediabetes and diabetes prevention. *Drugs*. 2015;75(10):1071–1094. doi:10.1007/s40265-015-0416-8
34. Magkos F, Hjorth MF, Astrup A. Diet and exercise in the prevention and treatment of type 2 diabetes mellitus. *Nat Rev Endocrinol*. 2020;16(10):545–555. doi:10.1038/s41574-020-0381-5