

Consensus-Driven Development of an Exercise Base Manual Programme for Prediabetic Patients: A Delphi Study

Sana Hafeez^{1,2}, Syed Shakil-Ur-Rehman¹, Saima Riaz³, Sidra Hafeez⁴, Jawad Salman Hafeez⁵, Hassan Mumtaz⁶ 

¹Faculty of Rehabilitation and Allied Health Sciences, Riphah International University, Lahore, 54000, Pakistan; ²Department of Physical Therapy and Rehabilitation Sciences, University of Management and Technology, Lahore, 54000, Pakistan; ³Ayesha Bakht Institute of Medical Sciences, Lahore, 54000, Pakistan; ⁴Department of Obstetrics and Gynecology, Services Hospital, Lahore, 54000, Pakistan; ⁵Department of Medicine, Mayo Hospital, Lahore, 54000, Pakistan; ⁶BPP University, London, UK

Correspondence: Hassan Mumtaz, BPP University, London, UK, Email hassanmumtaz.dr@gmail.com

Background: Prediabetes is a medical condition characterized by increased levels of glucose in the bloodstream. There are some lifestyle modifications like exercise, dietary patterns and prevention that can reverse prediabetes. Exercise plays an important role in controlling hyperglycemia and insulin sensitivity in prediabetes.

Purpose: The objective of the study is to develop a consensus driven exercise base manual programme for the prediabetic population using the Delphi Method.

Methods: A three-rounded Delphi study was conducted with 40 panelists either as Patient panelists (n = 20) or expert panelists (n=20). Round 1 included initial items selected from a systemic literature review. Initial recommendations were rated by panelists through a 5-point Likert scale. Additional items were also added by suggestion of Panelists in Round 1. Rounds 2 and 3 included all items from Round 1. All selected items were included in the final set of recommendations in Round 3 and rated as “Important” or “Very important” by at least 70% of all respondents. Descriptive data was analyzed by using SPSS version 25.

Results: 36 panellists (patients n = 17, professionals n = 19) completed Round 3. After three rounds of the Delphi process, panelists reached a consensus on the final version of the recommendations. Sixty-two items reached consensus in Round 1. In round 2 and 3 a total of sixty-four and sixty-three items were added, respectively. Fifty-seven of these reached consensus in round 3.

Conclusion: The exercise-based manual programme developed by Modified Delphi study provided disease prevention education, physical activity and dietary recommendations to improve glycemic control in the prediabetic population. The exercise manual programme along with lifestyle modifications contribute to public health by improving prediabetes levels and also addressing the modifiable risk factors. An exercise protocol needs time to mitigate hyperglycemia in prediabetic individuals and to help provide information at community level.

Keywords: exercise-based manual, prediabetes, glycemic control, education, physical activity, diet

Introduction

Prediabetes is a medical condition in which blood sugar levels have gradually increased in the bloodstream.¹ According to American Diabetes Association (ADA), a state of increased level but non-diabetes glycemia as indicated by a fasting plasma glucose (FPG) value of 5.6–6.9 mmol/L (impaired fasting glucose, IFG), a plasma glucose value of 7.8–11.0 mmol/L in a 2-h oral glucose tolerance test (OGTT) or an HbA1c value of 5.7–6.4% (39–47 mmol/mol) is known as prediabetes. It functions as a crucial indicator to developing diabetes and other severe health consequences.² The incidence of prediabetes has shown an upward trend in recent years presenting a substantial public health concern on a global scale.^{3,4} Simultaneous presence of insulin resistance and β -cell dysfunction abnormalities that start before glucose changes are detectable in patients with prediabetic state.⁵ The incidence of prediabetes is increasing globally and

by the end of 2030, 472 million people may be effected by it.^{6–8} In preceding years if prediabetes is untreated, individuals with diabetes may increase to 37%. Cardiovascular complications are also associated with diabetic population if untreated, which puts a burden on the prediabetes community.^{9–11}

In the upcoming years, prediabetes is associated with a substantial universal risk of 75% for developing type 2 diabetes. It is important to conduct precautionary trials, particularly for individuals who lead sedentary regimes in order to lessen the menace of diabetes mellitus.^{12,13} In prediabetic state, several studies showed that many identical risk factors for diabetes are already present in prediabetic state, many literature studies already advocated these finding.^{14–16}

Risk factors are classified into 2 types: modifiable and non-modifiable risk factors.¹⁷

Risk factors that cannot be changed, adjusted or controlled in prediabetic individuals such as age, race, family history and genetic composition are known as non-modifiable. Risk factors that can easily be improved by bringing recommended changes in the lifestyle or by optimizing pharmacotherapy attributes are known as modifiable risk factors.¹⁸ Behavioral risk factors include physical inactivity, poor diet, and alcohol drinking, while cardiometabolic risk factors are obesity, hypertension, and dyslipidemia.

As reported by the World Health Organization (WHO), Pakistan is in the list of top ten countries in terms of diabetes prevalence.¹⁹ About 19 million individuals have been diagnosed and another 10 million are considered to be at risk for developing this disease.^{20,21} Metabolic syndrome is included excessive adiposity and elevated triglyceride levels, hypertension, elevated blood sugar levels, insulin resistance, and sedentary lifestyles are all modifiable risk factors associated with type 2 diabetes mellitus.²² All patients with prediabetes should be monitored annually for the prevention of type 2 diabetes according to 2020 guidelines from the American Diabetes Association. For weight loss and physical activity improvement patients should be referred to Diabetes Prevention Programs.²³

Physical activity has been widely recognized as a necessary characteristic in the control and prevention of prediabetes. It has been proven that physical activity of 150mins per week plays an important role in controlling diabetes mellitus. Additionally, it can lead to improvement in insulin sensitivity, higher sugar level uptake by muscles, and general metabolic health.^{24,25}

A combination of different exercise treatments are essential for lowering the chances of diabetes mellitus and enhancing the body's insulin response.²⁶ Regular exercise improves cardiovascular health and improves glucose levels that enhances insulin uptake in skeletal muscles. Thus, it is an essential part of approaches to treating and preventing diabetes.^{27,28} Pakistan is significantly higher in prevalence rate of prediabetes as compared to previous estimates.²⁹ In the world of prediabetes, Pakistan is third most prevalent country after China and India according to the 10th iteration of the International Diabetes Federation (IDF) Atlas.³⁰

In 2022, estimated effected adults are 26.7% prone to diabetes in Pakistan. This results in a total of approximately 33,000,000 cases.^{20,31} There is a substantial burden of prediabetes with significant regional and gender differences in Pakistan. Focusing on early detection and lifestyle modifications, the high prevalence of prediabetes needs to be addressed with proper targeted interventions and resources.³²

Strategies and knowledge for prevention and management of prediabetes could raise awareness of the disease and lead to new policies. There is a lack of understanding about disease and knowledge of prevention that puts a burden on health systems. There are some cultural norms that do not allow outdoor physical activities. Implementation of an exercise manual program contributes to awareness of prediabetes and treatment strategies help in reducing modifiable risk factors that lessens the burden on public health policies. Low-cost exercise programme and educational materials help to lessen the burden on the healthcare system and spread awareness at community level. The main objective of this study is to develop a consensus driven exercise base manual programme for prediabetic population using the Delphi method.

Materials and Methods

Modified Delphi study consisted of three rounds. Delphi study was in line with recommendations for the Conducting and Reporting of Delphi Studies (CREDES) and reporting quality indicators.^{33,34} The study was done From October 2021 to March 2022. The study was approved by the Research and Ethics Committee of Faculty of Rehabilitation and Allied Health Sciences, Riphah International University, Lahore under registration no. REC/RCR&AHS/21/1103 and was

conducted in accordance with the ethical standards set by the Helsinki Declaration of 1975. All the participants were given an informed consent related to the study.

The study included the development of an exercise-based manual by panelists both patients and experts. Initial recommendations were included through systematic review. The systematic review was registered on PROSPERO with registry number CRD42023482857. Search engines (PubMed and Google Scholar) were used to extract material for the development of the manual by using the terms prediabetes state, exercise intervention, diet, and physical activity. A modified Delphi technique was employed, in which the initial round was developed from existing evidence (Figure 1). This approach was chosen to minimize the burden on panelists and optimize the quality of the recommendations.^{33,35} Whole Delphi process was supervised by 5 member committee (endocrinologists, medicine specialist, physical therapist, clinical nutritionist and patient with prediabetes). This committee was not part of the panels.

Delphi Expert Panel

Delphi panel included both patient and expert panelists. Minimum number of patients and panelists were selected by using stratified purposive sampling from key groups.³⁶ Patients were recruited through public health centers and endocrinology centers. In front of other panel members, patients were not permitted to share their details. Patient panelists who had experience of prediabetes state or known this condition were included in the study. Professionals were encouraged to share study details with other professionals and were recruited from all four provinces of Pakistan by

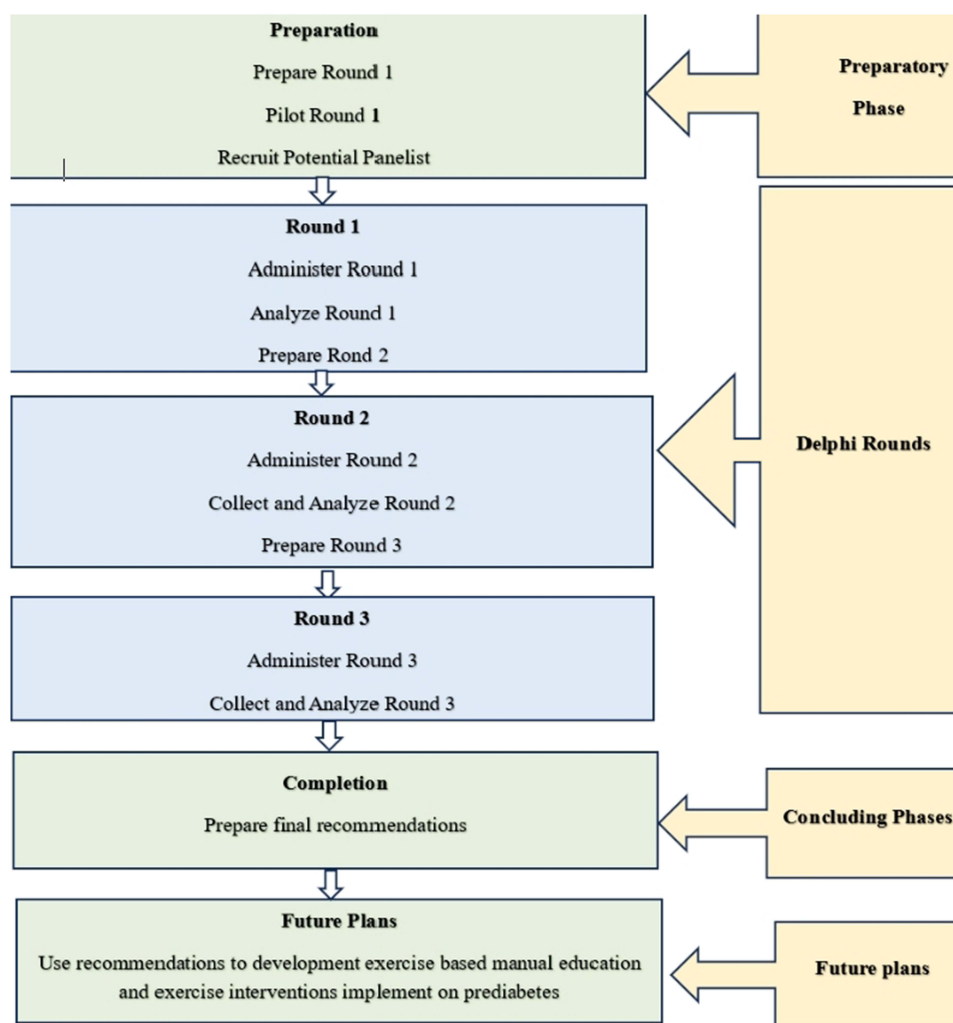


Figure 1 Delphi process flow chart.

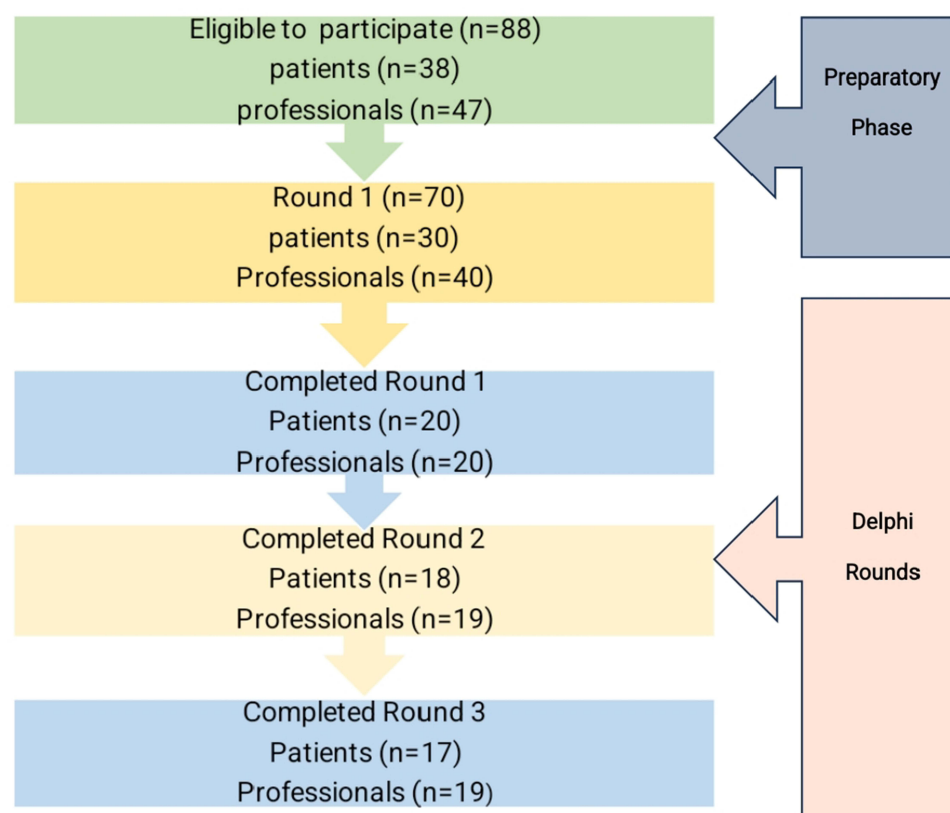


Figure 2 Expert Panel Flow Chart.

stratified purposive sampling. Professional panelists included in this study were medical specialist, endocrinologists, physiotherapists, clinical nutritionists with minimum of 5 years clinical experience and research activity/publications in relevant field. Data was collected from July 2021 to January 2022. Informative material was provided to panelists via email. Data was not shared with any panelists to maintain privacy. Reminders were given to panelists via telephone. Round 1 panelist took 30 to 45 mins to complete the round. Rounds 2 and 3 panelists took 15–25 mins to complete the round. Timeline between each round was 1.5 months. Every panelist adhered to strict compliance of time to complete the rounds (Figure 2).

Delphi Round 1

Round 1 consisted of main categories of exercise-based manual that were education, dietary and exercise recommendations from previous published research. These recommendations were based on material selected by systematic review.

Five-point Likert scale from Not at all important = 1 to Very important = 5 was used for rating and panelists were asked to use this scale for rating each recommendation item. Seven study team members that included two physical therapists, two medical specialists, one clinical nutritionist and two patient representatives performed a pilot test in round 1. It led to clarity of small wording changes; most importantly to make the items more applicable for clinical practice. Individuals were not part of the main expert panel who participated in the pilot testing before round 1.

Delphi Round 2

Round 2 consisted of all the items that were recommended from Round 1 to ensure all items had equal chance of reaching as high a level of consensus as possible. This approach was used on the prioritization of the items-based panelists' responses in the final round. Panelists' marked importance ratings for each item in round 1 and each item having three charts. In order to facilitate the development of consensus and re-evaluate their initial judgment, after round 1, a summary of the results of the preceding round was provided by panelists. Round 2 also provided the additional

recommendation items generated from Round 1. Panelists were asked to rate the importance of each item using a five-point Likert scale in Round 1.³⁷

Delphi Round 3

With the inclusion of all the round 2 items accompanied by three charts summarizing panelists and importance ratings of each item, round 3 followed the same format as previous rounds. Panelists were asked to rate the importance of each item using a five-point Likert scale in the preceding Rounds (Figure 3). Final consensus for recommendations were achieved by attaining 70% of ratings as “very important” and “important”.

The Data Structure of the Exercise-Based Manual

Extracting the material from research engines, current study followed the Delphi process to improve and validate the content.³⁸ The Delphi process involved 3 rounds of feedback and revisions from expert panelists in the relative domain of prediabetes, education, exercise, and nutrition. Each Delphi round consisted of panelists including medical specialists, endocrinologists, clinical nutritionists, physical therapists and patients. The diverse group of experts ensured that the manual covered a wide range of perceptions and proficiency. Participants were automatically added to remaining rounds who completed Round 1.³⁹ In round 1 of the Delphi process, forty panelists provided opinions on the initial draft of the manual and added some information related to the manual. Recommendations were updated at the end of each round. In round 2, thirty-seven panelists suggested additional comments which were used to make further modifications and development in the exercise-based manual. In the final third round, thirty-six panelists reviewed the final draft of the exercise-based manual. Their opinion confirmed that the manual was widespread, precise, and prepared for publication. After a critical process, the exercise-based manual was carefully crafted and validated by the expert panelists, while 57 items were reached consensus in the final manual.⁴⁰ This exercise-based manual provided impact on health care centers as it is easy to read and understand for sixth grade individuals and provided exercise contents that can be easily followed in busy routines and did not require any equipment.

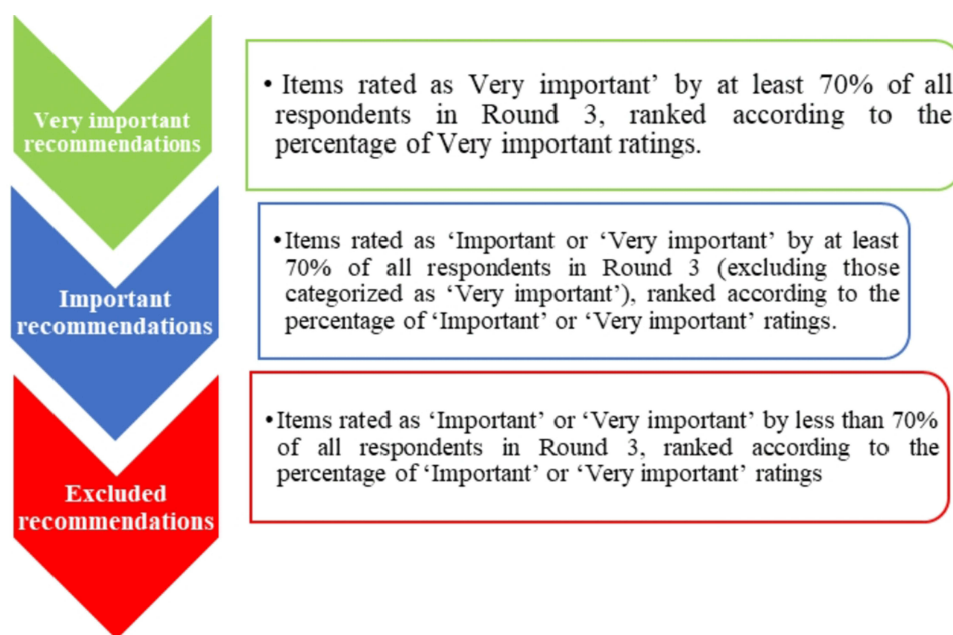


Figure 3 Expert panelist's consensus recommendations.

Language and Graphics of Manual

From the collected data, the first edition of the manual was designed to be simple language for those who can read, write and have completed at least primary school. A manual was designed by a graphic designer who did the manual's layout, customized images, and printed all the brochures flawlessly on A4 90g/m² paper.

Data Analysis

The Likert scale test was used for importance ratings using the statistical software Microsoft Excel 2016 and IBM SPSS Statistics 25. There are established guidelines for conducting Delphi studies.³⁴ The study calculated the percentage for the reached consensus, which was defined as a consensus of at least 70% of expert panelists rated an item as "Important" or "Very important". Whereas, the predetermined (<70%) consensus was excluded from the study (Figure 3).

Results

Ninety-five panelists were randomly selected and only seventy met the eligibility criteria of the study. Forty panelists formulated the expert panel and completed Round 1. Ninety-three and 90% of panellists completed Rounds 2 and 3, respectively (Figure 2). The professional panelist who was busy on some other tasks did not complete Round 2 and some other non-respondents provided no reasons for non-completion. Professional and patient demographics and characteristics are provided in Tables 1 and 2 respectively. All bold items in tables reached consensus at least 70% rating. These items were all developed from initial recommendations and included through systematic review with registry number CRD42023482857. Search engines (PubMed and Google Scholar) were used to extract material for the development of the manual by using the terms Prediabetes state, exercise intervention, diet, and physical activity.

Table 1 Professional Panelist Characteristics

Variables	Number of Professional Panelists n= 20
Workplace location	
Punjab	20
Current professional role	
Doctors	12
Physiotherapists	05
Clinical nutritionist	03
Years of experience as a health professional	
1–10	4
11–20	9
21–30	7
Age	
30–39 years	5
40–49 years	6
50–59 years	7
60–69 years	2
Gender	
Male	13
Female	7
Highest educational qualification	
FCPS	11
USMLE	2
MASTER	4
PHD	3
Current employment status	
Employed full time	16
Employed part-time	4

Table 2 Patient Panelist Category Characteristics

Demographics	Number of Patient Panelists n= 20
Age	
20–29 years	5
30–39 years	12
40–49 years	3
Gender	
Male	12
Female	8
Highest educational qualification	
Primary education	2
Secondary Education	4
Graduation	7
Post-graduation	7

Development of Exercise Based Manual Programme

Initial recommendations from literature were extracted and categorized into prediabetes knowledge, prediabetes health, prediabetes precautions, prediabetes diet recommendations, prediabetes exercise education, and prediabetes exercise delivery items. Panelists reached consensus on the final version of the exercise-based manual after completing all 3 rounds of the Delphi process. The study was long enough to complete the three Delphi rounds. In Round 1, a total of sixty-five items were primarily assessed by experts, of which 62 items reached consensus. In Round 2, 64 items were assessed but some new items were added, and consensus was reached for 61 items. Eventually in Round 3, n-63 items were assessed, and consensus was reached to finalize n-57 items by expert panelists (Table 3). Recommended items reached consensus if at least 70% rated the item as important and very important. All bold items in tables considered as final recommendations for manual.

Prediabetes Knowledge Items

This category included the items about prediabetes definition, causes, prevalence and diagnosis criteria. The importance of prediabetes knowledge was evaluated and consistently received high ratings of 95% “Important or Very Important” across all three rounds. Total 5 sub category items are included in final round 3. In round two, 2 items – cause of prediabetes and

Table 3 Recommendation of Total Items Summary

Items	Number of Recommendation Items					
	Round 1		Round 2		Round 3	
	Total	Reached Consensus	Total	Reached Consensus	Total	Reached Consensus
Prediabetes knowledge	3	3	5	5	5	5
Prediabetes health type	12	11	11	10	11	10
Prediabetes precautions type	09	08	08	7	08	06
Prediabetes-diet recommendations	12	12	12	12	12	09
Prediabetes exercise education	14	13	13	12	12	12
Prediabetes exercise delivery	15	15	15	15	15	15
All recommendation items	65	62	64	61	63	57

prevalence of prediabetes – were added. Experts recommended the specific topics within the Informative component, what is prediabetes, and diagnosis of prediabetes sustained a significance rating of 92% to 93% in three rounds (Table 4).

Prediabetes Health Items

This category included prediabetes warning signs and risk factors. Twelve items were included in round 1. Only 10 items reached consensus at the end of round 3. Items comparative thirst, warning signs and weights 20% more than ideal weight received consensus as “most important”. Item frequent infections showed “very important” from both professionals and patients (Table 5). Item generalized weakness showed “least important” consensus. Items Gestational diabetes and spend more than 6 hours sitting or lying down reached consensus as “Important”. Item warning signs and risk factors of prediabetes did not meet the consensus of 70% ratings.

Table 4 Total Prediabetes Knowledge Items: Importance Rating Summary

Total Prediabetes Knowledge Topics Items	% Important or Very Important Rating		
	Round 1 (n-40) %	Round 2 (n-37) %	Round (n-36) %
Informative component*	95	95	95
What is prediabetes*	89	88	87
Cause of prediabetes*	N/A	93	92
Prevalence of prediabetes*	N/A	85	92
Diagnosis of prediabetes**	92	93	93

Notes: **Very important. *Important. N/A, Not applicable because the item was not included in rounds (1, 2, 3). Items in bold text reached the consensus at the end of round 3.

Table 5 Total Prediabetes Health Items: Importance Ratings Summary

Total Prediabetes Health-Type Items	% Important or Very Important Rating		
	Round 1 (n-40) %	Round 2 (n-37) %	Round 3 (n-36) %
Warning signs and Risk factors of prediabetes*	15	N/A	N/A
Warning signs of prediabetes*	90	90	90
Comparatively increased thirst*	90	90	90
Increase in urination*	75	75	75
Frequent infection**	100	100	100
Generalized weakness*	75	78	38
Risk factors of prediabetes*	80	80	80
Weight 20% more than your ideal body weight*	90	90	90
Anxiety/stress*	83	83	83
Unhealthy diet*	90	90	90
Spend more than 6 hours/day by sitting or lying down other than sleeping*	90	90	90
Gestational diabetes*	85	85	85

Notes: **Very important. *Important. Items in bold reached the consensus at the end of round 3. Items in bold letters reached the consensus at the end of round 3.

Prediabetes Precautions Items

This category included monitoring and prevention of prediabetes. Nine items were included in round 1. Only six items reached consensus for final recommendations at the end of round 3. Item fasting blood glucose level reached consensus as important. Items monitoring of prediabetes, check weight maintenance and regular physical activity 150mins/week were prioritized as “Important” (Table 6). Item HbA1c after every 6 months prioritized as “Very Important”. Item monitoring and prevention of prediabetes did not reach consensus.

Prediabetes Diet Recommendation Items

This category included the food items allowed during prediabetes state and food to be avoided. Twelve items were added into round 1. Only 9 items reached consensus at the end of round 3. Item half plate filled with leafy vegetables reached prioritize as “very important”. Item food allowed, 20% lean protein such as chicken, mutton/beef (1–2 times/week) reached consensus as “important”. Limiting portion size of white bread and pasta rated as important. Limited usage of trans fat prioritized as “important”. Avoid refined sugar did not reach round 3 (Table 7).

Table 6 Total Prediabetes Precautions Items: Importance Rating Summary

Total Prediabetes Precaution Type Items	% Important or Very Important Rating		
	Round 1 (n-40) %	Round 2 (n-37) %	Round 3 (n-36) %
Monitoring and prevention of prediabetes	63	N/A	N/A
Monitoring of prediabetes	85	85	85
Fasting blood glucose level	78	78	85
HbA1C after every 6 months	90	91	90
Check weight maintenance	85	85	85
Prevention of prediabetes	85	85	85
Weight reduction	78	56	38
Regular physical activity 150mins /week	88	88	80
Take 6–8 hours' sleep	76	70	32

Note: Items in bold text reached the consensus at the end of round 3.

Table 7 Total Prediabetes Diet Recommendation Items: Importance Rating Summary

Total-Prediabetes-Diet Recommendations Items	% Important or Very Important Rating		
	Round 1 (n-40) %	Round 2 (n-37) %	Round 3 (n-36) %
Community education	88	85	38
Food allowed	85	80	80
Half plate filled with leafy vegetables	90	90	90
50–60% healthy carbohydrates such as beans, whole grain	78	70	40
20% lean protein such as chicken, fish	88	88	88

(Continued)

Table 7 (Continued).

Total-Prediabetes-Diet Recommendations Items	% Important or Very Important Rating		
	Round 1 (n-40) %	Round 2 (n-37) %	Round 3 (n-36) %
Mutton/beef (1–2 times/week)	85	85	85
Fibers such as fruits (1 small size apple/peach)	85	85	85
Food to avoid	77	81	79
Less intake of sugars, cakes/snacks	85	85	85
Limited use of saturated and trans fats such as fried chicken, fries	78	75	80
Limiting portion size of white bread, rice and pasta	78	88	88
Avoid refined sugar in tea	88	82	65

Notes: N/A, Not applicable because the item was not included in round 1. Items in bold text reached the consensus at the end of round 3.

Prediabetes Exercise Education Items

This category included exercise awareness and safety measures. Exercise education refers to knowledge of how to perform exercise and ways to prevent injuries during exercise. Education refers to spreading awareness about particular activity. Fourteen items were included in round 1. Only twelve items reached the final consensus at the end of round 3. Items exercise awareness and safety measures prioritized as “not important at all”. Items stop exercise if feeling pain/dizziness prioritized as “very important”. Item avoid fatigue received consensus as “most important”. Items “helps in reducing weight, improve glycemic control, improve insulin resistance reached consensus” as “Important”. Item warmup reached consensus as “important” (Table 8). Items improve physical fitness and helps in reducing weight reached consensus as “important”.

Table 8 Total Prediabetes Exercise Education Items: Importance Ratings Summary

Total Prediabetes Exercise Education Items	% Important or Very Important Rating		
	Round 1 (n-40) %	Round 2 (n-37) %	Round 3 (n-36) %
Exercise awareness and safety measures	30	N/A	N/A
Exercise awareness	70	40	N/A
Improve physical fitness	83	83	83
Helps in reducing weight	88	87	87
Improve glycemic control	85	85	85
Improve insulin sensitivity	85	85	85
Safety measures for exercise	88	88	88
Stop exercise if feeling pain/dizziness	90	90	90
Warmup before exercise	88	88	88
Cool down after exercise	70	86	89
Workout area free of obstacles and clutter	75	75	75

(Continued)

Table 8 (Continued).

Total Prediabetes Exercise Education Items	% Important or Very Important Rating		
	Round 1 (n-40) %	Round 2 (n-37) %	Round 3 (n-36) %
Inhale and exhale during exercise	83	83	83
Avoid fatigue	78	90	90
Know about your physical fitness	73	77	78

Note: Items in bold text reached the consensus at the end of round 3.

Prediabetes Exercise Delivery Items

This section included exercises mode both aerobic and resistance component as previous literature supports both exercise modes in helping to prevent prediabetes. Sixteen items were included in round 1. At the end of round 3 a final 16 items were prioritized as important or very important. One item “standing arm circles” included in round 2 as new item. Items standing criss cross crunches, exercise mode, aerobic component, and side lunges prioritized as “Very important” (Table 9). Items exercise protocol, resisted exercise, walk on spot, jumping jacks prioritized as “Important”. Resistance component and elbow plank items received consensus as “important”. Items exercise intensity and duration reached consensus as “important”. Items high knees, jumping jacks and walk on spot reached consensus as “important”.

Table 9 Total Prediabetes Exercise Delivery Items: Importance Ratings Summary

Total Prediabetes Exercise Delivery Items	% Important or Very Important Rating		
	Round 1 (n-40) %	Round 2 (n-37) %	Round 3 (n-36) %
Exercise protocol components for prediabetes*	32	N/A	N/A
Exercise mode*	90	87	93
Aerobic exercises*	88	82	89
Resisted exercises*	85	85	85
Exercise intensity and duration*	80	88	94
Exercise progression*	85	83	90
Aerobic component*	90	90	90
Walk on spot*	85	83	85
Standing arm circles*	N/A	80	90
Wall pushups*	88	82	89
Standing Criss cross crunches*	90	92	91
Jumping jacks*	83	79	83
Side lunges*	90	90	90
High knees*	82	88	88
Resisted component*	81	88	80
Elbow plank**	80	93	85

Notes: **Very important. *Important. N/A, Not applicable because the item was not included in round (1, 2). Items in bold text reached the consensus at the end of round 3.

Discussion

The main purpose of this Delphi study was consensus driven exercise base manual programme for prediabetes using Delphi technique. The contents of this manual were evaluated by expert panelists. This manual can potentially increase patient awareness about the importance of diet, lifestyle modification and exercise in controlling prediabetic state and could act as one of the strategies for the early prevention of prediabetes. This exercise base manual is different from previous strategies used to prevent prediabetes.^{41,42} The present study followed the Modified Delphi process in which 65 items were selected by panelists across the different categories while 57 items reached consensus among the participants. Exercise delivery recommendation items reached largest consensus both from patients and professionals. The process of modification and ranking of recommendation items remained comparatively persistent while the consensus reach fluctuated across the three rounds. This indicated that the participants effectively recognized and determined the most essential recommendations.

Some previous study showed inadequate prediabetes education and knowledge to prevent the changes in insulin resistance and need to improve massive screening of prediabetes management.⁴³ In current study exercise education and dietary methods used for prevention of disease. Consensus for exercise education reached almost 88%. In low-income countries literacy rates are low so need to educate people about prediabetes. The current study also examined prediabetes education importance including warning signs of prediabetes (90%), frequent infection (100%), ideal body weight (90%), unhealthy diet (90%), and spending more than 6 hours/day by sitting or lying down other than sleeping (90%) were all considered important or very important. This highlighted factor of prediabetes education helps identification and prevention of prediabetes. Marcotte et al focused-on diet control, physical activity and weight reduction in a lifestyle intervention program for prediabetes individuals. They found it very effective in lowering the chance of developing diabetes mellitus by 59% of population. They addressed the significance of numerous aspects of prediabetes administration to succeed in ideal effects. They found that a combination of physical and digital or remote methods was more effective than a single method. They also highlighted that there is a need for a multi-dimensional methodology for the management of prediabetes.^{44–48} In current study consensus on prediabetes exercise delivery and dietary recommendation reached about 85% ratings. Both patients and expert panelists agreed that this combination of exercise intervention and nutrition helped in minimizing prediabetes and reverse the progression of diabetes mellitus. In previous studies lifestyle modification improved prediabetes levels in high-risk patients. Prediabetes risk can be lowered by modifying dietary habits and exercise interventions.

In some previous studies prediabetes should be controlled specifically focused on physical activity. Pharmacotherapy and bariatric surgery may be considered in certain high-risk individuals or those who have not been able to achieve sufficient improvements through lifestyle changes alone.^{49,50} In current study non-pharmacotherapeutic interventions was used to improve the glycemic control. Experts reached the consensus on exercise interventions at least 90% ratings. This physical activity intervention was cost effective and put less burden on society and healthcare centers. These were mild to moderate low impact exercise interventions that can enhance the reversal of prediabetes.

American Diabetes Association deliberated the individuals who engaged moderate-intensity aerobic exercise per week including brisk walking, and cycling, swimming that recommended at least 150 minutes per week. They improved insulin impairment and sugar level control by enhancing glucose in muscles that increased insulin receptor sensitivity.^{51–55} In current study aerobic component reached almost 90% consensus to be the part of exercise protocol. Aerobic components walk on the spot, criss cross crunches and side lunges reached 90% consensus by the experts. Remaining aerobic components also reached 85% of consensus.

In previous studies resistance training exercises including weightlifting, and bodyweight exercises incorporated in prediabetic patients.^{56–59} They found the exercise program enhanced insulin sensitivity and glucose uptake in muscles, additionally they observed an increase in muscle mass and improved muscle fiber composition in prediabetes individuals. In current study resistance exercise used to improve the glycemic control. Around 93% consensus achieved to use resistance exercise for management of prediabetes.

Previous studies examined high-intensity interval training in prediabetes individuals. Their training program involved short bursts of high-intensity exercise followed by brief periods of rest. They also noted improvement in glucose levels,

glucose control, and insulin sensitivity in individuals with prediabetes. Their findings noted an increase in glycemic control, muscle fiber composition, and improved insulin signaling.^{60,61} In current study short periods of rest during aerobic and resistance exercises is recommended. Resistance exercises were also included in the recommendations to show improvement on glycemic control. But current study reached consensus on both resistance and aerobic exercises to control the prediabetes state. This study also added low impact exercise of moderate intensity.

The current study exercise-based manual in which combined aerobic and resistance training exercises were more effective than a single type of exercise. They also noted improvement in both insulin sensitivity and glucose uptake which leads to better glucose control and reduced risk of progressing to type 2 diabetes. In previous studies exercise guidelines for individuals with prediabetes including both aerobic and resistance training could improve metabolic control. Current recommendations for the control of prediabetes advice both aerobic and resistance training in individuals with prediabetes have demonstrated efficacy in improving HbA_{1c}.^{62–64}

Previous studies showed that detection and treatment of prediabetes is an effective strategy in diabetes prevention. Most patients with prediabetes are not aware of the condition and symptoms of prediabetes. Risk factors for prediabetes are gender, weight gain and sedentary lifestyle.^{65–67} In current study weight checking and physical activity were rated as “important” by panelists and reached 88% consensus. Checking HbA_{1c} reached consensus 90% and was rated as most important. Expert panelists recommended precautions and prevention important component for prediabetes.

Some previous studies mentioned that to control prediabetes dietary quality is an important factor. Progression from prediabetes to diabetes by 40~70% can be reduced by taking healthier dietary intake. While taking the controlled and balanced diet prediabetic persons can easily decrease the 40% of glycemic level, HbA_{1c} and BMI.^{68–70} In current study panelists recommended consensus on food to allowed and avoided in prediabetes. They gave 70% consensus on all items dietary recommendations. But item half plate filled with leafy vegetables was rated as 90% consensus.

The current exercise base manual facilitated education, dietary and exercise recommendations based on consensus by expert panelists. In future this exercise-based manual, however, has yet to be implemented practically on the population diagnosed with prediabetes. This is necessary to ensure that the target user accepts and benefits from this manual. Public health centers and hospital setups can also promote this manual to the general population which can help in the prevention of prediabetes. The relatively small sample size of the expert panel was one of our study's limitations, which may restrict the generalizability of the findings. Expert panels only included Asian experts that also effects the recommended items to be selected based on Asian regions.

Conclusion

The exercise-based manual programme developed by Modified Delphi study provided disease prevention, education, exercise intervention and dietary recommendations to improve glycemic control in prediabetic population. This exercise-based manual programme contributes to the prevention of the escalating prevalence of diabetes and the enhancement of public health outcomes by addressing modifiable risk factors and the potential of lifestyle modifications. This exercise programme aids in the dissemination of information regarding prediabetes at the community level and offers an exercise protocol to mitigate hyperglycemia in prediabetic individuals. Encouraging lifestyle modifications, such as weight reduction and regular physical activity can significantly impact prediabetes outcomes. This exercise manual lessens the burden on the health care system and provides a low-cost exercise programme with no use of special equipment. This exercise manual in future will check its impact on prediabetic population to show its effects on biochemical, physical and cardiorespiratory variables.

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Disclosure

The author(s) report no conflicts of interest in this work.

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