



# Systematic Review Effects of Additional Dietary Fiber Supplements on Pregnant Women with Gestational Diabetes: A Systematic Review and Meta-Analysis of Randomized Controlled Studies

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Abstract: The efficacy of different types and doses of dietary fiber supplementation in the treatment of gestational diabetes (GDM) remains controversial. The purpose of this study is to investigate the effect of dietary fiber on blood glucose control in pregnant women with gestational diabetes mellitus, and further observe the effect on their blood lipids and pregnancy outcomes. We searched on Web of Science, PubMed, Embase, Scopus, and Cochrane, and included several articles on additional fortification with dietary fiber for gestational diabetes interventions. This meta-analysis included 8 trials. We found that additional dietary fiber supplements significantly reduced fasting glucose (Hedges'g = -0.3; 95% CI [-0.49, -0.1]), two-hour postprandial glucose (Hedges'g = -0.69; 95% CI [-0.88, -0.51]), glycated hemoglobin (Hedges'g = -0.5; 95% CI [-0.68, -0.31]), TC (Hedges'g = -0.44; 95% CI [-0.69, -0.19]), TG (Hedges'g = -0.3; 95% CI [-0.4, -0.2]) and LDL-C (Hedges'g = -0.48; 95% CI [-0.63, -0.33]). It also significantly reduced preterm delivery (Hedges'g = 0.4, 95% CI [0.19~0.84]), cesarean delivery (Hedges'g = 0.6; 95% CI [0.37~0.97]), fetal distress (Hedges'g = 0.51; 95% CI [0.22~1.19]), and neonatal weight (Hedges'g = -0.17; 95% CI [ $-0.27 \sim -0.07$ ]). In a subgroup analysis comparing dietary fiber type and dose, insoluble dietary fiber was more effective than soluble dietary fiber in reducing fasting glucose (Hedges'g = -0.44; 95% CI [-0.52, -0.35]).  $\geq$ 12 g fiber per day may be more effective in improving glycemic lipid and pregnancy outcomes than <12 g/day, but the difference was not statistically significant. In conclusion, our meta-analysis showed that dietary fiber supplementation significantly improved glycolipid metabolism and pregnancy outcomes in gestational diabetes. Dietary fiber may be considered adjunctive therapy for gestational diabetes, and an additional supplement with insoluble dietary fiber is more recommended for those with poor fasting glucose. However, more high-quality studies are needed on the further effect of fiber type and the dose-effect relationship.

Keywords: dietary fiber; gestational diabetes; additional supplements

# 1. Introduction

Gestational diabetes mellitus (GDM) is usually defined as the first episode or finding of carbohydrate intolerance during pregnancy [1]. GDM increases the risk of maternal cardiovascular disease and type 2 diabetes in later life, the incidence of large births, and neonatal complications. There is also a long-term risk of obesity, type 2 diabetes, and cardiovascular disease in later offspring [2]. In a recent Japanese birth cohort study, it was found that mothers with gestational diabetes had a lower average gestational age, significantly heavier placental weight, and a higher relative risk of delivery complications and neonatal complications compared to normal pregnant women [3]. Results of a crosssectional study in Thailand from September 2018 to February 2019 showed an overall prevalence of gestational diabetes of 18.6%, significantly lower pregnancy weight gain, and a higher prevalence of pre-eclampsia and macrosomia in pregnant women with gestational



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diabetes compared to those without gestational diabetes [4]. Gestational diabetes was positively associated with the risk of offspring acute lymphoblastic leukemia (OR = 1.40, 95% CI = 1.12 to 1.75;  $I^2 = 0.0\%$ ) [5].

Treatment for gestational diabetes includes diet, lifestyle, and medication. Medication such as metformin, glyburide, or insulin is recommended only when diet and lifestyle changes are not effective in controlling blood glucose levels [6]. Nutrition has an important role in the risk of GDM, and nutritional supplements may be a safe and effective means of treating GDM, such as Inositol, Vitamins, Minerals, Fatty Acids, Probiotics, and Fiber [7]. Fiber is part of a healthy diet for diabetes treatment. A meta-analysis of diabetes showed that a high-fiber diet is an important component of diabetes management, improving glycemic control, lipids, body weight, and inflammatory markers, and reducing premature mortality, with significant effects for any fiber type, any dose, or any type of diabetes, but there may be a dose-effect relationship, and an increase in fiber intake of 15 or 35 g per day may be a reasonable goal [8]. The prevalence of GDM in China is 17.5%, and an analysis of 9317 women found that women with the highest pre-pregnancy dietary fiber intake had a significantly lower risk of developing gestational diabetes mellitus. In addition, increased GI or GL and decreased fiber intake during gestation were independently associated with poor development of fasting glucose, glycated hemoglobin, and insulin resistance [9]. The intake of dietary fiber in various types of foods during mid-pregnancy may be associated with the risk of GDM. In particular, a diet rich in total fiber and fruit fiber may help improve blood glucose [10]. In a randomized controlled trial, dietary blueberry and soluble fiber supplements reduced the risk of GDM in obese women [11].

The preventive and ameliorative effects of dietary fiber on GDM have been well documented in many studies, but there are few studies on the effects of additional dietary fiber supplements and different fiber types and doses on GDM, for this reason, this study conducted a meta-analysis from a systematic search of randomized controlled trials to assess the effects of fiber fortification on indicators of glycemic control, lipids, pregnancy outcome, and neonatal outcome in GDM, and further subgroup analyses were conducted to investigate the differences in dietary fiber type and amount of fortification on these outcomes.

# 2. Methods

This systematic review and meta-analyses were conducted following Cochrane's PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, registration number CRD42022363892.

# 2.1. Search Strategy

The articles were searched in five databases: Pubmed, Embase, Scopus, Cochrane, and Web of Science. The search string included ("Dietary Fiber" OR "Dietary Fibers" OR "Fibers, Dietary" OR "Fiber, Dietary" OR "Wheat Bran" OR "Bran, Wheat" OR "Brans, Wheat" OR "Wheat Brans" OR "Roughage" OR "Roughages" OR "inulin" OR "inuline" OR "pectin" OR "beta glucan" OR "fructose oligosaccharide" OR "oligofructose") AND ("Diabetes, Gestational" OR "Diabetes, Pregnancy-Induced" OR "Diabetes, Pregnancy Induced" OR "Pregnancy-Induced Diabetes" OR "Gestational Diabetes" OR "Diabetes".

# 2.2. Inclusion and Exclusion Criteria

Literature was included if it met the following criteria: (1) Study was a randomized controlled trial, (2) At least one outcome of interest was reported—Fasting plasma glucose, Blood glucose two hours after a meal, (3) The intervention included only dietary fiber products compared with the control group and, (4) The intervention objects were pregnant women with gestational diabetes mellitus. Exclusion criteria were as follow: (1) There were other interventions besides fiber fortification and (2) The experiment was not designed for

eligible human subjects. When there was a difference in literature screening, the authors (J.H.S, J.J.W and W.Q.M) discussed and solved it.

# 2.3. Data Extraction and Quality Assessment

Two independent reviewers extracted the following basic information from selected articles: author, year, sample size, blinding method, duration of intervention, type of fiber, intervention dose, and changes in key indicators before and after the intervention. Two articles were excluded because lacking standard deviation and the authors contacted by email did not respond.

The quality of the included literature was evaluated using an improved Cochrane bias risk assessment tool. Assessing the risk of bias: (1) random sequence generation; (2) allocation concealment; (3) blinding of participants and personnel; (4) blinding of outcome assessment; (5) incomplete outcome data; (6) selective outcome reporting; (7) other bias. Three levels were described for each item: "high risk", "low risk", and "unclear".

#### 2.4. Statistical Analysis

RevMan 5.4 was used for quality assessment provided by Cochrane collaborate and Standard errors (SE) reported in articles were converted to SD. Units for TG, TC, HDL-C, LDL-C, and blood glucose concentrations were standardized to mmol/L. Stata 17 was used for the statistical analysis of the extracted data.

p < 0.05 was considered statistically significant. Heterogeneity was assessed by the  $l^2$  index,  $l^2$  is the portion(%) of the total variability attributed to pure heterogeneity among studies. When  $l^2$  is 0, it means that studies are completely homogeneous. If  $l^2 > 50\%$ , it indicates there is heterogeneity in studies. We used the random effects model for analysis. Estimates were statistically different (p < 0.05; both overall effect sizes fell outside the 95% CI of the counterpart) and the boundaries of the 95% CI had the same sign, bias can be considered influential.

Subgroup analysis was performed by fiber type (soluble fiber, insoluble fiber, and complex) and the amount of fortified fiber per day (<12 g/day vs.  $\geq$ 12 g/day). The 12 g quantity of fiber was determined by the difference between the average dietary intake of 13 g of fiber [9] and the recommended intake of 25 g to 30 g for women in the second trimester of pregnancy.

#### 3. Results

#### 3.1. Search Results and Characteristics

Figure 1 shows a flow chart from search to meta-analysis. A total of 614 articles were obtained, and after duplicate removal of 243 articles, 371 articles remained for screening. 361 articles were excluded based on the criteria. Two articles of the remaining 10 articles [12,13] were excluded, one because a loading meal method was used and the other because the authors could not be contacted to obtain useful data, and a total of eight articles were finally used for the systematic review and meta-analysis.

Table 1 summarized the characteristics of the study, which included eight articles with durations ranging from 2 to 12 weeks. There were three articles with <12 g/day fiber fortification and five articles with  $\geq$ 12 g/day fiber fortification. Three articles used soluble fiber-fortified foods, three articles used insoluble fiber-fortified foods, and two articles used complex fiber. Each randomized controlled trial had a corresponding control diet or non-fortified placebo. The results obtained were: fasting glucose, two-hour postprandial glucose, glycated hemoglobin, triglycerides, cholesterol, HDL, LDL, and pregnancy outcome (preterm delivery, cesarean delivery, fetal distress, and neonatal weight).





NO	First Author, Year	Population Size and Description	Intervention Duration (Weeks)	Study Design	Control Food and Description	Fiber and Description
1	Ahmad, et al., 2013 [14]	36 subjects with GDM(18 I; 13 C)	2	Parallel Single-blind	low GL diet	15 g insoluble fiber (wheat bran)
2	Pan, et al., 2015 [15]	96 subjects with GDM (48 I; 48 C)	4	Parallel Single-blind	Diet therapy	10.5 g insoluble fiber (wheat fiber)
3	Deng, et al., 2019 [16]	100 subjects with GDM (51 I; 49 C)	12	Parallel Single-blind	Basic dietary nutrition support treatment	20 g soluble dietary fiber (Fiber polysaccharide)
4	Wu, et al., 2020 [17]	84 subjects with GDM (42 I; 42 C)	8	Parallel Single-blind	Personalized diet control	15 g soluble dietary fiber (Inulin, stachyose, microcrystalline cellulose, oat fiber)
5	Miao, et al., 2021 [18]	100 subjects with GDM (50 I; 50 C)	4	Parallel Single-blind	Dietary guidelines	10 g soluble dietary fiber (Inulin)
6	Zahra, et al., 2021 [19]	104 subjects with GDM (53 I; 51 C)	4	Parallel Single-blind	Dietary guidelines	30 g insoluble fiber (oat bran)
7	Wang, et al., 2021 [20]	120 subjects with GDM (60 I; 60 C)	8	Parallel Single-blind	Dietary guidelines	19 g complex dietary fiber (Ricnoat)
8	Zhang, et al., 2021 [21]	112 subjects with GDM (56 I; 56 C)	8	Parallel Single-blind	Dietary guidelines	9.5 g complex dietary fiber (Ricnoat)

Gestational diabetes mellitus (GDM); Glycemic Index (GI); Intervention (I); Control (C).

The risk of bias assessment is shown in Figure 2. In terms of the random sequence generation method, five had sufficient random components with a low risk of bias, two were determined to be unclear, and one was high risk. For allocation hiding, two articles performed low risk and six were unclear. Most randomized controlled trials were singleblinded, and three articles were unclearly blinded. Six articles indicated blinding of outcome assessors, and two were unclear.



Figure 2. The risk of bias assessment.

#### 3.3. Meta-Analyses

The overall meta-analysis effect sizes and confidence intervals for each outcome are summarized in Table 2. Overall, there was a high degree of heterogeneity in fasting glucose and triglycerides.

Table 2. Effect sizes and confidence intervals for each outcome
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Outcome	Hedges' g [95% CI]	<i>I</i> <sup>2</sup> Value (%)	p Value
fasting glucose	-0.3 [-0.49, -0.1]	83	0.003
Two-hour plasma glucose	-0.69[-0.88, -0.51]	49	< 0.001
HbA1c	-0.5[-0.68, -0.31]	0	< 0.001
Number of qualified blood glucose	5.27 [2.56, 10.83]	0	< 0.001
TC	-0.44 [-0.69, -0.19]	56	< 0.001
TG	-0.3 [ $-0.4$ , $-0.2$ ]	0	< 0.001
HDL	-0.03 [ $-0.06$ , $0.11$ ]	0	0.58
LDL	-0.48[-0.63, -0.33]	0	< 0.001
preterm delivery	0.4 [0.19, 0.84]	0	0.01
cesarean delivery	0.6 [0.37, 0.97]	0	0.04
fetal distress	0.51 [0.22, 1.19]	0	0.12
neonatal weight	$-0.17 \left[-0.27, -0.07\right]$	0	< 0.001

Glycated hemoglobin (HbA1c); Serum total cholesterol (TC); Triglyceride (TG); High-density lipoprotein cholesterol (HDL); Low-density lipoprotein cholesterol (LDL).

# 3.4. Serum Glucose Outcomes

The Figure 3 showed a significant decrease in fasting glucose (Hedges'g = -0.3; 95% CI [-0.49, -0.1];  $I^2 = 83\%$ ; 8 articles) and two-hour plasma glucose (Hedges'g = -0.69; 95% CI [-0.88, -0.51];  $I^2 = 49\%$ ; 7 articles), glycated hemoglobin (Hedges'g = -0.5; 95% CI [-0.68, -0.31];  $I^2 = 0\%$ ; 2 articles), and number of qualified blood glucose increased significantly (Hedges'g = 5.27; 95% CI [2.56, 10.83];  $I^2 = 0\%$ ; 2 articles).

	dietary fiber Contro			ontrol			Mean Difference	Mean Difference	
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	IV, Random, 95% CI
Ahmad, et al. 2013	4.79	0.63	18	5.37	1.15	13	5.4%	-0.58 [-1.27, 0.11]	
Deng, et al. 2019	4.69	0.96	51	5.62	0.81	49	11.0%	-0.93 [-1.28, -0.58]	
Miao, et al. 2021	4.97	0.55	50	5.01	0.69	50	13.4%	-0.04 [-0.28, 0.20]	
Pan, et al. 2015	4.94	0.61	48	5.21	0.92	48	11.8%	-0.27 [-0.58, 0.04]	
Wang, et al. 2021	4.47	0.5	60	4.48	0.45	60	15.1%	-0.01 [-0.18, 0.16]	-+-
Wu, et al. 2020	4.98	0.69	42	5.18	0.73	42	12.0%	-0.20 [-0.50, 0.10]	
Zahra, et al. 2021	4.7	0.16	53	5.15	0.28	51	16.6%	-0.45 [-0.54, -0.36]	+
Zhang, et al. 2021	4.95	0.48	56	5.13	0.57	56	14.6%	-0.18 [-0.38, 0.02]	
Total (95% CI) 378 30						369	100.0%	-0.30 [-0.49, -0.10]	◆
Heterogeneity: Tau <sup>2</sup> =	= 0.06; 0	$Chi^2 =$	41.16,	df = 7	(P < 0	.00001	); $I^2 = 83$	%	
lest for overall effect	z = 3.0	DZ (P =	0.003	)					Favours [dietary fiber] Favours [control]

							(A)			
diet	ary fib	er	С	ontrol			Mean Difference	Mean Difference		
Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	IV, Random, 95% CI		
6.39	1.01	18	7.61	1.04	13	5.5%	-1.22 [-1.95, -0.49]			
6.1	1.57	51	7.02	1.76	49	6.6%	-0.92 [-1.57, -0.27]			
7.14	0.52	48	7.9	1.24	48	14.1%	-0.76 [-1.14, -0.38]			
5.72	0.83	60	6.19	0.93	60	17.2%	-0.47 [-0.79, -0.15]			
6.13	1.14	42	7.19	1.35	42	9.0%	-1.06 [-1.59, -0.53]			
5.78	0.3	53	6.53	0.63	51	24.8%	-0.75 [-0.94, -0.56]			
6.57	0.67	56	7	0.51	56	22.9%	-0.43 [-0.65, -0.21]			
		328			319	100.0%	-0.69 [-0.88, -0.51]	◆		
0.03; 0 Z = 7.2	Chi² = ?7 (P <	11.68, 0.000	df = 6 01)	(P = 0)	.07); I <sup>2</sup>	= 49%		-2 -1 0 1 2 Favours (dietary fiber) Favours (control)		
	diet <u>Mean</u> 6.39 6.1 7.14 5.72 6.13 5.78 6.57 0.03; 0 Z = 7.2	dietary fib           Mean         SD $6.39$ $1.01$ $6.1$ $1.57$ $7.14$ $0.52$ $5.72$ $0.83$ $6.13$ $1.14$ $5.78$ $0.3$ $6.57$ $0.67$ $0.03$ ; $Chi^2 =$ $Z = 7.27$ (P <	dietary fiber           Mean         SD         Total           6.39         1.01         18           6.1         1.57         51           7.14         0.52         48           5.72         0.83         60           6.13         1.14         42           5.78         0.3         53           6.57         0.67         56           328           0.03; Chi <sup>2</sup> = 11.68,         2 = 7.27 (P < 0.000	dietary fiber         C           Mean         SD         Total         Mean $6.39$ $1.01$ $18$ $7.61$ $6.1$ $1.57$ $51$ $7.02$ $7.14$ $0.52$ $48$ $7.99$ $5.72$ $0.83$ $60$ $6.19$ $6.13$ $1.14$ $42$ $7.19$ $5.78$ $0.3$ $53$ $6.53$ $6.57$ $0.67$ $56$ $7$ <b>328</b> $0.03$ ; $Chi^2 = 11.68$ , $df = 6$ $Z = 7.27$ ( $P < 0.0000$ U) $Y$	Generation with the system of the sy	dietary fiber         Colspan="3">Colspan="3"           Mean         SD         Total         Mean         SD         Total           6.3         1.01         18         7.61         1.04         13           6.1         1.57         51         7.02         1.76         49           7.14         0.52         48         7.9         1.24         48           5.72         0.83         60         6.19         0.93         600           6.13         1.14         42         7.19         1.35         42           5.78         0.3         53         6.53         0.63         51           6.57         0.67         56         7         0.51         56           0.63         53         6.53         0.63         51           0.03; Chi <sup>2</sup> = 11.68, df = 6 (P = 0.07); l <sup>2</sup> 319           0.03; Chi <sup>2</sup> = 1.168, df = 6 (P = 0.07); l <sup>2</sup> 319	Control           Mean         SD         Total         Mean         SD         Total         Weight           6.3         1.01         18         7.61         1.04         13         5.5%           6.1         1.57         51         7.02         1.76         448         6.6%           7.14         0.52         48         7.9         1.24         48         14.1%           5.72         0.83         60         6.19         0.93         600         17.2%           6.13         1.14         42         7.19         1.35         42         9.0%           5.78         0.3         53         6.53         0.63         51         24.8%           6.57         0.67         56         7         0.51         56         22.9%           328         319         100.0%           0.03; Chi <sup>2</sup> = 11.68, df = 6 (P = 0.07); l <sup>2</sup> = 49%         2         7.9         1.4         49%	(A)           Mear         SD         Total         Mean         SD         Total         Mean         Meight         IV. Random, 95% CI           6.39         1.01         18         7.61         1.04         13         5.5%         -1.22 [-1.95, -0.49]           6.1         1.57         51         7.02         1.76         49         6.6%         -0.92 [-1.57, -0.27]           7.14         0.52         48         7.9         1.24         48         14.1%         -0.76 [-1.14, -0.38]           5.72         0.83         60         6.19         0.93         60         17.2%         -0.47 [-0.79, -0.15]           6.13         1.14         42         7.19         1.35         42         9.0%         -1.06 [-1.59, -0.53]           5.78         0.3         53         6.53         0.63         51         24.8%         -0.75 [-0.94, -0.56]           6.57         0.67         56         7         0.51         56         22.9%         -0.43 [-0.65, -0.21]           328         319         100.0%         -0.69 [-0.88, -0.51]           0.03; Chi <sup>2</sup> = 11.68, df = 6 (P = 0.07); l <sup>2</sup> = 49%         2         49%         2         2.9%		

	diet	ary fib	er	С	ontrol			Mean Difference	Mean Diff	erence
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	IV, Random,	, 95% CI
Deng, et al. 2019	4.63	1.12	51	5.33	1.73	49	10.9%	-0.70 [-1.27, -0.13]		
Miao, et al. 2021	4.61	0.64	50	5.08	0.34	50	89.1%	-0.47 [-0.67, -0.27]		
Total (95% CI)			101			99	100.0%	-0.50 [-0.68, -0.31]	•	
Heterogeneity: Tau <sup>2</sup> =	0.00; 0	$Chi^2 =$	0.55, d	$If = 1 \; (F$	P = 0.4	16); I <sup>2</sup> =	= 0%		-2 -1 0	1 2
Test for overall effect:	Z = 5.1	L2 (P <	0.000	01)					Favours [dietary fiber] F	avours [control]

						(C)	
	dietary	fiber	Conti	rol		Odds Ratio	Odds Ratio
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Random, 95% CI	M-H, Random, 95% Cl
Ahmad, et al. 2013	11	18	3	13	20.2%	5.24 [1.06, 25.97]	
Zhang, et al. 2021	40	56	18	56	79.8%	5.28 [2.36, 11.82]	-∎-
Total (95% CI)		74		69	100.0%	5.27 [2.56, 10.83]	•
Total events	51		21				
Heterogeneity: Tau <sup>2</sup> =	0.00; Ch	$i^2 = 0.0$	0, df = 1	I (P = 0)	).99); I <sup>2</sup> =	= 0%	
Test for overall effect:	Z = 4.52	(P < 0.	00001)				Favours [dietary fiber] Favours [control]

(D)

**Figure 3.** Forest plot for the overall meta-analysis of Serum glucose outcomes: (**A**) fasting glucose (mmol/L); (**B**) 2 h plasma glucose (mmol/L); (**C**) HbA1c (mmol/L); (**D**) Number of qualified blood glucose [14–21].

# 3.5. Serum Lipid Outcome

The Figure 4 showed an improvement in lipids after fiber food supplement, with a decrease in TC (Hedges'g = -0.44; 95% CI [-0.69, -0.19];  $I^2 = 56\%$ ; 4 articles), TG (Hedges'g = -0.3; 95% CI [-0.4, -0.2];  $I^2 = 0\%$ ; 4 articles), decreased LDL-C (Hedges'g = -0.48; 95% CI [-0.63, -0.33];  $I^2 = 0\%$ ; 2 articles), however HDL-C was not significantly different (Hedges'g = 0.03; 95% CI [-0.06, 0.11];  $I^2 = 0\%$ ; 2 articles).

(B)

Total (95% CI)

Study or Subgroup       Mean       SD       Total       Meight       N       Andom, 95% CI       IV, Random, 95% CI         Deng, et al. 2019       6.14       1.43       50       6.55       6.67       51       4.45       0.56       49       33.0% $-0.70[-0.94, -0.46]$ Miao, et al. 2021       6.14       1.43       50       6.49       1.25       50       13.4% $-0.21[-0.79, 0.37]$ $-0.70[-0.94, 0.60]$ Yang, et al. 2021       5.01       0.63       1.21       60       6.49       1.29       0.01       16.44       1.43       50 $-0.41[-0.69, -0.19]$ Heterogeneity: Tau"       0.03; Ch² = 6.83, df = 3 (P = 0.08); P² = 56%       209       207       100.0% $-0.41[-0.69, -0.19]$ $-2$ $-1$ $-2$ $-1$ $-2$ $-1$ $-2$ $-1$ $-2$ $-1$ $-2$ $-1$ $-2$ $-1$ $-2$ $-1$ $-2$ $-1$ $-2$ $-1$ $-2$ $-1$ $-2$ $-1$ $-2$ $-1$ $-2$ $-2$ $-2$ $-2$ $-2$ $-2$ $-2$ $-2$ $-2$ $-2$ $-2$ $-2$ $-2$ <		dietary fiber Control						Mean Difference	Mean Difference	
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	IV, Random, 95% CI
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$	Deng, et al. 2019	3.75	0.67	51	4.45	0.56	49	33.0%	-0.70 [-0.94, -0.46]	
Pan, et al. 2015 $^{-1}$ 5.01 0.53 48 5.3 0.57 48 34.8% -0.29[-0.51, -0.07] Wang, et al. 2021 6.08 1.21 60 6.49 1.29 60 18.8% -0.41 [-0.66, 0.04] Total (95% CI) Test for overall effect: Z = 3.43 (P = 0.006) CA Test for overall effect: Z = 3.43 (P = 0.006) CA CAL [-0.69, -0.19] (A) CA Mean Difference IV, Random, 95% CI Mean Difference IV, Random, 95% CI Mean Difference IV, Random, 95% CI Mean Difference IV, Random, 95% CI Total (95% CI) Total (95% CI) Total (95% CI) CO Total V Wang, et al. 2021 1.17 0.49 60 1.75 0.49 60 26.0% 0.04 [-0.70, -0.20] Heterogeneity: Tau <sup>2</sup> = 0.00; Chi <sup>2</sup> = 2.10, df = 3 (P = 0.55); l <sup>2</sup> = 0% Total (95% CI) Total V Wang, et al. 2021 1.17 0.49 60 1.75 0.49 50 774 0.00% -0.30 [-0.40, -0.20] Heterogeneity: Tau <sup>2</sup> = 0.00; Chi <sup>2</sup> = 2.10, df = 3 (P = 0.55); l <sup>2</sup> = 0% Total (95% CI) Total V Wang, et al. 2021 1.17 0.49 60 1.75 0.49 60 26.0% 0.04 [-0.14, 0.22] Total (95% CI) Mean Difference IV, Random, 95% CI IV, Random, 95% CI Mean Difference IV, Random, 95% CI IV, Random,	Miao, et al. 2021	6.14	1.43	50	6.35	1.52	50	13.4%	-0.21 [-0.79, 0.37]	
Wang, et al. 2021       6.08       1.21       6.0       6.49       1.29       6.0       18.8%       -0.41 [-0.66, 0.04]         Total (95% CI)       209       207       100.0%       -0.44 [-0.69, -0.19]         Heterogeneity: Tau <sup>2</sup> = 0.03; Chi <sup>2</sup> = 6.83, df = 3 (P = 0.006); P <sup>2</sup> = 56%       (A)         (A)         dietary fiber       Control         Mean       SD Total Mean       SD Total Mean       Mean SD Total Mean       Meint SD Total Mean       Meint SD Total Mean       Mean SD Total Mean SD Tot	Pan, et al. 2015	5.01	0.53	48	5.3	0.57	48	34.8%	-0.29 [-0.51, -0.07]	
Total (95% CI)       209       207       100.0%       -0.44 [-0.69, -0.19]         Heterogeneity: Tau <sup>2</sup> = 0.03; Ch <sup>2</sup> = 6.83, df = 3 (P = 0.08); P = 56%         (A)         Study or Subgroup       Mean       SD       Total Weight       N. Random, 95% CI         Nano, et al. 2019       Control       Mean Difference       N. Random, 95% CI         Nano, et al. 2017       2.79       0.43       SD       Total Weight       N. Random, 95% CI         Mean Difference       N. Random, 95% CI       Mean Difference         Nano, et al. 2017       2.79       0.41 [-0.70, -0.12]         Total 055       1.65       0.72       SD       Total Weight       N. Random, 95% CI         Maa, et al. 2021       2.00; Chi <sup>2</sup> = 3.10, df = 3 (P = 0.55); I <sup>2</sup> = 0%         Total 095% CI       Mean Difference       N. Random, 95% CI         Mean Difference       N. Random, 95% CI       Mean Difference         VI Station of the towel	Wang, et al. 2021	6.08	1.21	60	6.49	1.29	60	18.8%	-0.41 [-0.86, 0.04]	
Heterogeneity: Tau <sup>2</sup> = 0.03; Chi <sup>2</sup> = 6.83, df = 3 (P = 0.08); l <sup>2</sup> = 56% Test for overall effect: Z = 3.43 (P = 0.0006) (A)	Total (95% CI)			209			207	100.0%	-0.44 [-0.69, -0.19]	•
Test for overall effect: Z = 3.43 (P = 0.0006)         Favours [dietary fiber]       Favours [control]         Favours [dietary fiber]       Favours [control]         Study or Subgroup       Mean SD Total Mean SD Total Weight IV, Random, 95% CI       IV, Random, 95% CI         Deng, et al. 2015       1.44 0.28       Control       Mean Difference       IV, Random, 95% CI         Total Mean SD Total Mean SD Total Weight IV, Random, 95% CI       IV, Random, 95% CI         IV, Random, 95% CI         Mean Difference       Mean Difference         Mean Difference       IV, Random, 95% CI         IV, Random, 95% CI         IV, Random, 95% CI         Total Mean SD Total Mean SD Total Meight IV, Random, 95% CI       IV, Random, 95% CI         IV, Random, 95% CI         IV, Random, 95% CI         IV, Random, 95% CI         IV, Random, 95% CI         IV, Random, 95% CI         IV, Random, 95% CI         IV, Random, 95% CI         IV, Random, 95% CI         IV, Random, 95% CI <td>Heterogeneity: Tau<sup>2</sup> =</td> <td>0.03; 0</td> <td><math>Chi^2 = 6</math></td> <td></td>	Heterogeneity: Tau <sup>2</sup> =	0.03; 0	$Chi^2 = 6$							
(A)         Study or Subgroup       Mean       SD       Total       Mean       SD       Total       Mean       Difference       Mean Difference         Deng, et al. 2019 <sup>++++</sup> 1.65       0.72       51       2.06       0.76       49       12.2%       -0.41 [-0.70, -0.12]         Mao, et al. 2021 <sup>+++++++++++++++++++++++++++++++++++</sup>	Test for overall effect:	Z = 3.4	13 (P =	0.0006	5)					Favours [dietary fiber] Favours [control]
Study or Subgroup         Mean         SD         Total         Mean         SD         Total         Weight         N, Random, 95% CI         N, Random, 95% CI           Deng, et al. 2019         1.65         0.72         51         2.06         0.76         49         12.2%         -0.41         [-0.70, -0.12]           Miao, et al. 2021         2.07         0.46         50         3.16         0.43         50         33.8%         -0.37         [-0.70, -0.20]           Pan, et al. 2021         3.05         1.01         60         3.23         1.47         60         5.1%         -0.31 [-0.36, 0.27]           Total (95% CI)         209         207         100.0%         -0.30 [-0.40, -0.20]         -1         -2         -1         0         1         2           Test for overall effect: Z = 5.83         (P < 0.000 U)         50         74.0%         0.30 [-0.40, -0.20]         -2         -1         0         1         2           Wang, et al. 2021         1.01         60         3.28         D         Total         Mean Difference         IV, Random, 95% CI         IV, Random, 95% CI           Wang, et al. 2021         1.21         0.25         50         1.10         100.0%         0.02 [-0.08, 0.12]									(A)	
Study or Subgroup         Mean         SD         Total         Mean         SD         Total         Weight         IV, Random, 95% CI         IV, Random, 95% CI           Deng, et al. 2019 <sup>11</sup> 1.65         0.72         51         2.06         0.76         49         12.2%         -0.41         (-0.70, -0.12)		diet	ary fib	er	Co	ontrol			Mean Difference	Mean Difference
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	IV, Random, 95% CI
Miao, et al. 2021       2.79       0.46       50       3.16       0.43       50       33.8%       -0.37       [-0.54, -0.20]         Pan, et al. 2015       1.44       0.28       48       1.68       0.43       48       48.9%       -0.24       [-0.39, -0.09]         Wang, et al. 2021       3.05       1.01       60       3.23       1.47       60       5.1%       -0.18       [-0.63, 0.27]         Total (95% CI)       209       207       100.0%       -0.30       [-0.40, -0.20]       -2       -1       0       1       2         Fest for overall effect: Z = 0.00; Chi <sup>2</sup> = 2.10, df = 3 (P = 0.55); l <sup>2</sup> = 0%       Exercise       B       Mean Difference       Mean Difference       Mean Difference       Mean Difference       Mean Difference       IV, Random, 95% CI         Miao, et al. 2021       100       100       20       20       50       7 total       Mean Difference       Mean Difference <td>Deng, et al. 2019</td> <td>1.65</td> <td>0.72</td> <td>51</td> <td>2.06</td> <td>0.76</td> <td>49</td> <td>12.2%</td> <td>-0.41 [-0.70, -0.12]</td> <td></td>	Deng, et al. 2019	1.65	0.72	51	2.06	0.76	49	12.2%	-0.41 [-0.70, -0.12]	
Pan, et al. 2015       1.44       0.28       48       1.68       0.43       48       48.9% $-0.24$ [ $-0.39$ , $-0.09$ ]         Wang, et al. 2021       3.05       1.01       60       3.23       1.47       60       5.1% $-0.18$ [ $-0.63$ , $0.27$ ]         Total (95% CI)       209       207       100.0% $-0.30$ [ $-0.40$ , $-0.20$ ] $-2$ $-1$ $0$ $1$ $2$ Test for overall effect: Z = 5.83 (P < 0.00001)       Mean       SD       Total       Mean       SD       Total       Mean       SD       Total       Weight       IV, Random, 95% CI         Miao, et al. 2021       1.21       0.25       50       1.19       0.28       50       74.0%       0.02 [ $-0.08$ , 0.12]       Mean Difference       Mean Difference       Mean Difference       IV, Random, 95% CI         Miao, et al. 2021       1.10       1.10       1.10       100.0%       0.03 [ $-0.06$ , 0.11] $-2$ $-1$ $0$ $1$ $2$ $-2$ $-1$ $0$ $1$ $2$ $0$ $0.03$ [ $-0.06$ , 0.11] $0.2$ $0$ $0$ $0$ $0$ $0$ $0$ $0$ $0$ $0$ $0$ $0$ $0$	Miao, et al. 2021	2.79	0.46	50	3.16	0.43	50	33.8%	-0.37 [-0.54, -0.20]	
Wang, et al. 2021       3.05       1.01       60       3.23       1.47       60       5.1% $-0.18$ [ $-0.63, 0.27$ ]         Total (95% Cl)       209       207       100.% $-0.30$ [ $-0.40, -0.20$ ] $-0.30$ [ $-0.40, -0.20$ ]         Heterogeneity: Tau <sup>2</sup> = 0.00; Chi <sup>2</sup> = 2.10, df = 3 (P = 0.55); I <sup>2</sup> = 0%       E       E       Hean Difference       Mean Difference         Study or Subgroup       Mean       SD       Total       Mean       SD       Total       Weight       N. Random, 95% Cl       Nean Difference         Miao, et al. 2021       1.21       0.25       50       1.10       100.0%       0.03 [ $-0.06, 0.11$ ] $-2$ $-1$ $-2$ $-1$ $0$ $1$ $0.30$ [ $-0.40, -0.20$ ]         Miao, et al. 2021       Aug       SD       Total       Mean       SD       Total       Weight       N. Random, 95% Cl       N. Random, 95% Cl         Total (95% Cl)       1.21       0.25       50       1.10       100.0%       0.03 [ $-0.06, 0.11$ ] $-2$ $-1$ $-2$ $-1$ $-2$ $-1$ $-2$ $-1$ $-2$ $-1$ $-2$ $-1$ $-2$ $-1$ $-2$ $-1$ $-2$ $-1$ $-2$	Pan, et al. 2015	1.44	0.28	48	1.68	0.43	48	48.9%	-0.24 [-0.39, -0.09]	
Total (95% Cl)       209       207       100.0% $-0.30$ [ $-0.40$ , $-0.20$ ]         Heterogeneity: Tau <sup>2</sup> = 0.00; Chi <sup>2</sup> = 2.10, df = 3 (P = 0.55); l <sup>2</sup> = 0% $-2$ $-1$ $0$ $1$ $2$ Test for overall effect: Z = 5.83 (P < $0.00001$ ) $B$ $P$ $0.55$ ; l <sup>2</sup> = 0% $P$	Wang, et al. 2021 ``	3.05	1.01	60	3.23	1.47	60	5.1%	-0.18 [-0.63, 0.27]	
Heterogeneity: Tau <sup>2</sup> = 0.00; Chi <sup>2</sup> = 2.10, df = 3 (P = 0.55); l <sup>2</sup> = 0%         Test for overall effect: Z = 5.83 (P < 0.00001)         (B)         Mean Difference         Study or Subgroup       Mean SD Total Mean SD Total Weight       Mean Difference         Mean 2021       (IV, Random, 95% CI         Item in SD Total Mean SD Total Mean SD Total Weight       Mean Difference         Mean Difference         Nean 2021         1.21       0.25       50       1.19       0.28       50       74.0%       0.02 [-0.08, 0.12]       IV, Random, 95% CI         Total (95% CI)       110       1000%       O.03 [-0.06, 0.11]         Heterogeneity: Tau <sup>2</sup> = 0.00; Chi <sup>2</sup> = 0.04, df = 1 (P = 0.85); l <sup>2</sup> = 0%       Control       Mean Difference         Study or Subgroup       dietary fiber       Control       Mean Difference         Mean Difference       Nean Difference         Total Mean       SD Total Weight       Mean Difference         Total (95% CI)       Control       Mean Difference	Total (95% CI)			209			207	100.0%	-0.30 [-0.40, -0.20]	•
Test for overall effect: Z = 5.83 (P < 0.00001)         Test for overall effect: Z = 5.83 (P < 0.00001)         (B)         Giudary fiber]       Favours [control]         Study or Subgroup       Mean       SD       Total       Mean       SD       Total       Mean Difference         Miao, et al. 2021       1.21       0.25       50       1.19       0.28       50       74.0%       0.02 [-0.08, 0.12]       Mean Difference       Weand, 0.03       Mean Difference       Wean Difference       Mean Difference       Mean Difference	Heterogeneity: Tau <sup>2</sup> = 0.00° Chi <sup>2</sup> = 2.10 df = 3 (P = 0.55): $l^2$ = 0%									
(B)Study or Subgroupdietary fiberMeanSDTotalMeanSDTotalMeanDifferenceMiao, et al. 20211.210.25501.190.285074.0%0.02 [-0.08, 0.12]Wang, et al. 20211.210.25501.190.285074.0%0.02 [-0.08, 0.12]Total (95% Cl)110100.0%0.03 [-0.06, 0.11]Image: colspan="6">Image: colspan="6">Image: colspan="6">Total (95% Cl)Heterogeneity:Tau²0.00;Chi²Chi<²Image: colspan="6">ComponeTotal (95% Cl)110100.0%0.03 [-0.06, 0.11]Image: colspan="6">Image: colspan="6">Image: colspan="6">Image: colspan="6">Mean DifferenceMeterogeneity:Tau²0.00;Chi²ChiImage: colspan="6">Image: colspan="6">Mean DifferenceTotal (95% Cl)110100.0%0.03 [-0.06, 0.11]Image: colspan="6">Image: colspan="6">Image: colspan="6">Image: colspan="6">Mean DifferenceMeterogeneity:Tau²0.00;Chi²Image: colspan="6">ComponeTest for overall effect:Z = 0.55;F = 0.58;Image: colspan="6">Mean DifferenceMiao, et al. 2021MeanSDTotalMeanSDTotalMeanMiao, et al. 20213.370.47503.870.365081.2%-0.50 [-0.66, -0.34]Image: colspan="6">Image: colspan="6">Image: colspan="6">Mean DifferenceMiao, et al. 2021 <td colspan="9">Test for overall effect: <math>Z = 5.83</math> (P &lt; 0.00001)</td> <td></td>	Test for overall effect: $Z = 5.83$ (P < 0.00001)									
Study or SubgroupMeanSDTotalMeanSDTotalWeight<	Heterogeneity: Tau <sup>2</sup> = Test for overall effect:	= 0.00; 0 Z = 5.8	Chi <sup>2</sup> = 2 33 (P <	0.0000	r = 3 (P 01)	- 0.5	5), T =	070		Favours [dietary fiber] Favours [control]
Study or Subgroup         Mean         SD         Total         Mean         SD         Total         Weight         IV, Random, 95% CI         IV, Random, 95% CI           Miao, et al. 2021         1.21         0.25         50         1.19         0.28         50         74.0%         0.02 [-0.08, 0.12]           Wang, et al. 2021         1.79         0.49         60         1.75         0.49         60         26.0%         0.04 [-0.14, 0.22]           Total (95% CI)         110         110         110         0.03 [-0.06, 0.11]         -2         -2         -1         0         1         2         2         2         -2         -1         0         1         2         2         2         2         2         -2         -1         0         1         2         2         2         2         -2         -1         0         1         2         2         2         2         2         2         2         2         2         3         2         3         1         0         0.03         1         0.03         1         0         0         0         0         0         0         1         2         3         3         3         3	Heterogeneity: I au <sup>+</sup> = Test for overall effect:	= 0.00; 0 Z = 5.8	Chi <sup>2</sup> = 2 33 (P <	0.0000	r = 3 (P 01)	- 0.5	5), 1 =	070	(B)	-2 -1 0 1 2 Favours [dietary fiber] Favours [control]
Miao, et al. 2021       1.21       0.25       50       1.19       0.28       50       74.0%       0.02 [-0.08, 0.12]         Wang, et al. 2021       1.79       0.49       60       1.75       0.49       60       26.0%       0.04 [-0.14, 0.22]         Total (95% Cl)       110       110       110       0.03 [-0.06, 0.11]         Heterogeneity: Tau <sup>2</sup> = 0.00; Chi <sup>2</sup> = 0.04, df = 1 (P = 0.85); l <sup>2</sup> = 0%       0.03 [-0.06, 0.11]         Test for overall effect: Z = 0.55 (P = 0.58)       Control       Mean Difference       Mean Difference         Kudy or Subgroup       Mean       SD       Total       Weight       Weight       N. Random, 95% Cl         Miao, et al. 2021       3.37       0.47       50       3.87       0.36       50       81.2%       -0.50 [-0.66, -0.34]	Heterogeneity: Tau* = Test for overall effect:	= 0.00; ( Z = 5.8	Chi <sup>2</sup> = 2 33 (P <	0.0000	r = 3 (P 01) C	ontro	5), 1 =	0,0	(B) Mean Difference	-2 -1 0 1 2 Favours [dietary fiber] Favours [control] Mean Difference
Wang, et al. 2021 $1.79$ $0.49$ $60$ $1.75$ $0.49$ $60$ $26.0\%$ $0.04$ $-0.14$ , $0.22$ Total (95% CI)       110       110       110 $100.0\%$ $0.03$ $-0.06$ , $0.11$ Heterogeneity: Tau <sup>2</sup> = 0.00; Chi <sup>2</sup> = 0.04, df = 1 (P = 0.85); l <sup>2</sup> = 0% $0.03$ $-0.06$ , $0.11$ $-2$ $-1$ $0$ $1$ $2$ $-2$ $-1$ $0$ $1$ $2$ $-2$ $-1$ $0$ $1$ $2$ $-2$ $-1$ $0$ $1$ $2$ $-2$ $-1$ $0$ $1$ $2$ $-2$ $-1$ $0$ $1$ $2$ $-2$ $-1$ $0$ $1$ $2$ $-2$ $-1$ $0$ $1$ $2$ $-2$ $-1$ $0$ $1$ $2$ $-2$ $-1$ $0$ $1$ $2$ $-2$ $-1$ $0$ $1$ $2$ $-2$ $-1$ $0$ $1$ $2$ $-2$ $-1$ $0$ $1$ $2$ $-2$ $-1$ $0$ $1$ $2$ $-2$ $-1$ $0$ $0$ <	Heterogeneity: Tau <sup>+</sup> = Test for overall effect: Study or Subgroup	2 = 5.8 die Mean	Chi <sup>2</sup> = 2 33 (P < tary fik	0.0000 Der Total	r = 3 (P )1) C Mean	ontrol SD		Weight	(B) Mean Difference IV, Random, 95% CI	-2 -1 0 1 2 Favours [dietary fiber] Favours [control] Mean Difference IV, Random, 95% CI
Total (95% Cl)       110       110       100.0%       0.03 [-0.06, 0.11]         Heterogeneity: Tau <sup>2</sup> = 0.00; Chi <sup>2</sup> = 0.04, df = 1 (P = 0.85); l <sup>2</sup> = 0%       0.03 [-0.06, 0.11]       -2       -1       0       1       2         Test for overall effect: Z = 0.55 (P = 0.58) $V = 0.85$ ; l <sup>2</sup> = 0%         (C)         Study or Subgroup       Mean       SD       Total       Mean       SD       Total       Mean       Mean<	Heterogeneity: Tau* = Test for overall effect: Study or Subgroup Miao, et al. 2021	c 0.00; 0 Z = 5.8 die <u>Mean</u> 1.21	chi <sup>2</sup> = 2 33 (P < tary fit 50 0.25	2.10, di 0.0000 Der Total 50	r = 3 (P D1) C <u>Mean</u> 1.19	ontrol 5D 0.28	1 Total 50	Weight 74.0%	(B) Mean Difference IV, Random, 95% CI 0.02 [-0.08, 0.12]	-2 -1 0 1 2 Favours [dietary fiber] Favours [control] Mean Difference IV, Random, 95% CI
Heterogeneity: $Tau^2 = 0.00$ ; $Chi^2 = 0.04$ , $df = 1$ (P = 0.85); $I^2 = 0\%$ Test for overall effect: Z = 0.55 (P = 0.58)(C)Study or SubgroupMean SD Total Mean SD Total WeightMean DifferenceMiao, et al. 20213.370.47503.870.365081.2%-0.50 [-0.66, -0.34]	Heterogeneity: Tau* =         Test for overall effect:         Study or Subgroup         Miao, et al. 2021         Wang, et al. 2021	e 0.00; 0 Z = 5.8 die Mean 1.21 1.79	Chi <sup>2</sup> = 2 33 (P < tary fit 50 0.25 0.49	2.10, di 0.0000 Der Total 50 60	C Mean 1.19 1.75	ontrol SD 0.28 0.49	<b>Total</b> 50 60	Weight 74.0% 26.0%	(B) Mean Difference IV, Random, 95% CI 0.02 [-0.08, 0.12] 0.04 [-0.14, 0.22]	-2 -1 0 1 2 Favours [dietary fiber] Favours [control] Mean Difference IV, Random, 95% CI
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	Heterogeneity: Tau* =         Test for overall effect:         Study or Subgroup         Miao, et al. 2021         Wang, et al. 2021         Total (95% CI)	e 0.00; C Z = 5.8 Mean 1.21 1.79	Chi <sup>2</sup> = 2 33 (P < tary fik 50 0.25 0.49	2.10, di 0.0000 Der <u>Total</u> 50 60 <b>110</b>	r = 3 (P 01) C Mean 1.19 1.75	ontrol SD 0.28 0.49	<b>Total</b> 50 60 <b>110</b>	Weight 74.0% 26.0% 100.0%	(B) Mean Difference IV, Random, 95% CI 0.02 [-0.08, 0.12] 0.04 [-0.14, 0.22] 0.03 [-0.06, 0.11]	-2 -1 0 1 2 Favours [dietary fiber] Favours [control] Mean Difference IV, Random, 95% CI
(C)         dietary fiber       Control       Mean Difference       Mean Difference         Study or Subgroup       Mean       SD       Total       Mean       SD       Total       Weight       IV, Random, 95% CI       IV, Random, 95% CI         Miao, et al. 2021       3.37       0.47       50       3.87       0.36       50       81.2%       -0.50 [-0.66, -0.34]       Image: Colored	Heterogeneity: Tau* =         Test for overall effect:         Study or Subgroup         Miao, et al. 2021         Wang, et al. 2021         Total (95% CI)         Heterogeneity: Tau² =	<pre></pre>	Chi <sup>2</sup> = 2 33 (P < tary fik 5D 0.25 0.49 Chi <sup>2</sup> =	2.10, a 0.0000 Der Total 50 60 110 0.04, c	r = 3 (P D1) C <u>Mean</u> 1.19 1.75	$\frac{\text{ontrol}}{\text{SD}}$ $0.28$ $0.49$ $P = 0.8$	Total 50 60 110 85); 1 <sup>2</sup> =	Weight 74.0% 26.0% 100.0% = 0%	(B) Mean Difference IV, Random, 95% CI 0.02 [-0.08, 0.12] 0.04 [-0.14, 0.22] 0.03 [-0.06, 0.11]	-2 -1 0 1 2 Favours [dietary fiber] Favours [control] Mean Difference IV, Random, 95% Cl
Study or Subgroup     Mean     SD     Total     Mean     SD     Total     Weight     Mean Difference     Mean Difference       Miao, et al. 2021     3.37     0.47     50     3.87     0.36     50     81.2%     -0.50 [-0.66, -0.34]     Image: Control in the second control in the secon	Heterogeneity: Tau* =         Test for overall effect:         Study or Subgroup         Miao, et al. 2021         Wang, et al. 2021         Total (95% CI)         Heterogeneity: Tau* =         Test for overall effect	<pre>die die Mean 1.21 1.79 = 0.00; t: Z = 0.</pre>	Chi <sup>2</sup> = 2 33 (P < 	2.10, di 0.0000 Der <u>Total</u> 50 60 <b>110</b> 0.04, c = 0.58)	r = 3 (P )1) C <u>Mean</u> 1.19 1.75	ontrolSD0.280.49 $P = 0.8$	Total 50 60 110 85); I <sup>2</sup> =	Weight           74.0%           26.0%           100.0%           = 0%	(B) Mean Difference IV, Random, 95% CI 0.02 [-0.08, 0.12] 0.04 [-0.14, 0.22] 0.03 [-0.06, 0.11]	-2 -1 0 1 2 Favours [dietary fiber] Favours [control]
Study or Subgroup         Mean         SD         Total         Mean         SD         Total         Weight         IV, Random, 95% CI         IV, Random, 95% CI           Miao, et al. 2021         3.37         0.47         50         3.87         0.36         50         81.2%         -0.50 [-0.66, -0.34]         IV, Random, 95% CI	Heterogeneity: Tau* =         Test for overall effect:         Miao, et al. 2021         Wang, et al. 2021         Total (95% CI)         Heterogeneity: Tau* =         Test for overall effect	die <u>die</u> <u>Mean</u> 1.21 1.79 = 0.00; :: Z = 0.	Chi <sup>2</sup> = 2 33 (P < <b>tary fik</b> <b>SD</b> 0.25 0.49 Chi <sup>2</sup> = 55 (P =	2.10, di 0.0000 Der <u>Total</u> 50 60 <b>110</b> 0.04, c = 0.58)	r = 3 (P D1) C Mean 1.19 1.75	<b>ontrol</b> <b>SD</b> 0.28 0.49 P = 0.8	Total 50 60 <b>110</b> 85); I <sup>2</sup> =	Weight 74.0% 26.0% 100.0%	(B) Mean Difference IV, Random, 95% CI 0.02 [-0.08, 0.12] 0.04 [-0.14, 0.22] 0.03 [-0.06, 0.11] - (C)	-2 -1 0 1 2 Favours [dietary fiber] Favours [control] Mean Difference IV, Random, 95% CI -2 -1 0 1 2 Favours [dietary fiber] Favours [control]
Miao, et al. 2021 3.37 0.47 50 3.87 0.36 50 81.2% -0.50 [-0.66, -0.34]	Heterogeneity: Tau <sup>2</sup> = Test for overall effect: Miao, et al. 2021 Wang, et al. 2021 Total (95% CI) Heterogeneity: Tau <sup>2</sup> Test for overall effect	<pre>die die <u>Mean</u> 1.21 1.79 = 0.00; :: Z = 0.</pre>	Chi² = 2         33 (P <         tary file         0.25         0.49         Chi² =         55 (P =         55 (P =	2.10, di 0.0000 Der <u>Total</u> 50 60 <b>110</b> 0.04, c = 0.58)	r = 3 (P D1) C Mean 1.19 1.75 If = 1 (I	$\frac{\text{ontrol}}{\text{SD}}$ $\frac{\text{O}}{0.28}$ $0.49$ $P = 0.3$ $\frac{1}{2}$	<b>Total</b> 50 60 <b>110</b> 85); I <sup>2</sup> =	Weight 74.0% 26.0% 100.0% = 0%	(B) Mean Difference IV, Random, 95% CI 0.02 [-0.08, 0.12] 0.04 [-0.14, 0.22] 0.03 [-0.06, 0.11] (C) Mean Difference	-2 -1 0 1 2 Favours [dietary fiber] Favours [control] Mean Difference IV, Random, 95% CI -2 -1 0 1 2 Favours [dietary fiber] Favours [control] Mean Difference
	Heterogeneity: Tau* =         Test for overall effect:         Miao, et al. 2021         Wang, et al. 2021         Total (95% CI)         Heterogeneity: Tau* =         Test for overall effect         Study or Subgroup	<pre>die die <u>Mean</u> 1.21 1.79 = 0.00; :: Z = 0. die Mean</pre>	Lhi <sup>2</sup> = 2         33 (P <	2.10, di 0.0000 Der <u>Total</u> 50 60 110 0.04, c = 0.58) Der Total	r = 3 (P D1) C Mean 1.19 1.75 If = 1 (I Mean	ontrol $SD$ 0.28 0.49 $P = 0.3$ Sontro SD	Total 50 60 110 85); I <sup>2</sup> =	Weight 74.0% 26.0% 100.0% = 0% Weight	(B) Mean Difference IV, Random, 95% CI 0.02 [-0.08, 0.12] 0.04 [-0.14, 0.22] 0.03 [-0.06, 0.11] (C) Mean Difference IV, Random, 95% CI	-2 -1 0 1 2 Favours [dietary fiber] Favours [control] Mean Difference IV, Random, 95% CI -2 -1 0 1 2 Favours [dietary fiber] Favours [control] Mean Difference IV, Random, 95% CI
Wang, et al. 2021 3.08 0.89 60 3.48 1.01 60 18.8% -0.40 [-0.74, -0.06]	Heterogeneity: Tau* =         Test for overall effect:         Miao, et al. 2021         Wang, et al. 2021         Total (95% CI)         Heterogeneity: Tau*         Test for overall effect         Study or Subgroup         Miao, et al. 2021	<pre>die die Mean 1.21 1.79 = 0.00; :: Z = 0. die Mean 3.37</pre>	Chi² = 2         33 (P <	2.10, di 0.0000 Der <u>Total</u> 50 60 110 0.04, c = 0.58) Der <u>Total</u> 50 50 50 50 50 50 50 50 50 50	r = 3 (P D1) C Mean 1.19 1.75 If = 1 (I Mean 3.87	$\frac{\text{ontrol}}{\text{SD}}$ $0.28$ $0.49$ $P = 0.3$ $\frac{\text{contro}}{\text{SD}}$ $0.36$	Total 50 60 110 85); I <sup>2</sup> = I Total 50	Weight           74.0%         26.0%           100.0%         0%           • 0%         0%	(B) Mean Difference IV, Random, 95% CI 0.02 [-0.08, 0.12] 0.04 [-0.14, 0.22] 0.03 [-0.06, 0.11] (C) Mean Difference IV, Random, 95% CI -0.50 [-0.66, -0.34]	-2 -1 0 1 2 Favours [dietary fiber] Favours [control] Mean Difference IV, Random, 95% Cl -2 -1 0 1 2 Favours [dietary fiber] Favours [control] Mean Difference IV, Random, 95% Cl

(D)

110 100.0% -0.48 [-0.63, -0.33]

**Figure 4.** Forest plot for the overall meta-analysis of Serum lipid outcome: (**A**) Serum total cholesterol (TC, mmol/L); (**B**) Triglyceride (TG, mmol/L); (**C**) High-density lipoprotein cholesterol (HDL, mmol/L); (**D**) Low-density lipoprotein cholesterol (LDL, mmol/L) [15,16,18–21].

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Favours [dietary fiber] Favours [control]

# 3.6. Pregnancy and Neonatal Outcomes

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Heterogeneity:  $Tau^2 = 0.00$ ;  $Chi^2 = 0.27$ , df = 1 (P = 0.60);  $I^2 = 0\%$ 

Test for overall effect: Z = 6.38 (P < 0.00001)

As shown in Figure 5, compared to placebo or control, there were significantly fewer preterm deliveries (Hedges'g = 0.4, 95% CI [0.19, 0.84];  $I^2 = 0\%$ ; 3 articles), significantly fewer cesarean deliveries (Hedges'g = 0.6; 95% CI [0.37~0.97];  $I^2 = 0\%$ ; 3 articles), and significantly fewer fetal distress (Hedges'g = 0.51; 95% CI [0.22~1.19];  $I^2 = 0\%$ ; 2 articles) and a significant reduction in neonatal weight (Hedges'g = -0.17; 95% CI [ $-0.27\sim-0.07$ ];  $I^2 = 0\%$ ; 2 articles).



**Figure 5.** Forest plot for the overall meta-analysis of Pregnancy and neonatal outcomes: (**A**) preterm deliveries; (**B**) cesarean deliveries; (**C**) fetal distress; (**D**) neonatal weight [15–17,21].

#### 3.7. Subgroup Analyses on Fiber Type, Fiber Quantity

Table 3 shows the results of the subgroup analysis. HbA1c, TC, TG, HDL, LDL, and pregnancy outcomes were not analyzed in subgroups of fiber type, because in at least one group there was only one comparison. Subgroup analysis for HDL, LDL, and pregnancy outcomes on fiber quantity was not conducted for the same reason.

			Fiber Type	Fiber Quantity						
Outcome	Insoluble		Soluble		Complex		<12 g		≥12 g	
	Hedges'g (95% CI)	I <sup>2</sup> (%)								
fasting glucose	-0.44 [-0.52, -0.35]	33.8	-0.38 [-0.88, 0.13]	36.5	-0.09 [-0.25, 0.08]	29.7	-0.15 [-0.29, -0.02]	0	-0.40 [-0.69, -0.11]	87
2-h glucose	-0.77 [-0.94, -0.61]	44.4	-1.00 [-1.42, -0.59]	15.5	-0.44 [-0.62, -0.26]	40.1	-0.56 [-0.87, -0.24]	54	-0.84 [-1.22, -0.46]	51
TC	—	_	—	—	—	_	-0.28 [-0.49, -0.07]	0	-0.62 [-0.87, -0.36]	20
TG	_	—	_	_	_	_	-0.30 [-0.42, -0.17]	21	-0.34 [-0.58, -0.09]	0

**Table 3.** The results of subgroup analysis.

Serum total cholesterol (TC); Triglyceride (TG).

#### 3.8. Fiber Type

The intervention effect of insoluble dietary fiber on fasting glucose was reduced (Hedges'g = -0.44; 95% CI [-0.52, -0.35];  $I^2 = 33.8\%$ ) but not for soluble and complex fiber. 2-h glucose was not affected by fiber type (Figure 6).



**Figure 6.** Forest plots of subgroup analysis of fiber type on (**A**) fasting glucose (mmol/L) and (**B**) 2-h glucose (mmol/L) [14–21].

#### 3.9. Fiber Quantity

The  $\geq 12$  g group significantly reduced fasting glucose (Hedges'g = -0.40; 95% CI [-0.69, -0.11];  $I^2$  = 87%), but two-hour postprandial glucose (Hedges'g = -0.84; 95% CI [-1.22, -0.46];  $I^2$  = 51%), TC (Hedges'g = -0.62; 95% CI [-0.87, -0.36];  $I^2$  = 20%), and

TG (Hedges'g = 0.34; 95% CI [-0.58, -0.09];  $I^2 = 0$ %) were not statistically significant (Figures 7 and 8). In addition, Figure 9 shows that there was no significant difference between the different doses in pregnancy outcomes and neonatal outcomes.

	fiber Control Mean						Mean Difference	rence Mean Difference				
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	IV, Random, 95% CI			
4.1.1 <16 g												
Ahmad, et al 2013	4.79	0.63	18	5.27	1.15	13	5.3%	-0.48 [-1.17, 0.21]				
Miao, et al 2021	4.97	0.55	50	5.01	0.69	50	13.4%	-0.04 [-0.28, 0.20]				
Pan, et al 2015	4.94	0.61	48	5.21	0.92	48	11.8%	-0.27 [-0.58, 0.04]				
Wu, et al 2020	4.98	0.69	42	5.18	0.73	42	12.0%	-0.20 [-0.50, 0.10]				
Zhang, et al 2021	4.95	0.48	56	5.13	0.57	56	14.6%	-0.18 [-0.38, 0.02]				
Subtotal (95% CI)			214			209	57.2%	-0.17 [-0.29, -0.05]	•			
Heterogeneity: $Tau^2 = 0.00$ ; $Chi^2 = 2.30$ , $df = 4$ (P = 0.68); $l^2 = 0\%$												
Test for overall effect:	Z = 2.7	73 (P =	0.006)									
4.1.2 ≥16 g												
Deng, et al 2019	4.69	0.96	51	5.62	0.81	49	11.0%	-0.93 [-1.28, -0.58]	_ <b>_</b>			
Wang, et al 2021	4.47	0.5	60	4.48	0.45	60	15.2%	-0.01 [-0.18, 0.16]	+			
Zahra, et al 2021	4.7	0.16	53	5.15	0.28	51	16.6%	-0.45 [-0.54, -0.36]	*			
Subtotal (95% CI)			164			160	42.8%	-0.44 [-0.83, -0.04]				
Heterogeneity: $Tau^2 =$	0.11; 0	$Chi^2 = 1$	30.18, 0	df = 2 (	P < 0.	00001)	$I^2 = 93\%$	6				
Test for overall effect:	Z = 2.1	17 (P =	0.03)									
						260	100.00/					
Total (95% CI)			378			369	100.0%	-0.29 [-0.48, -0.10]				
Heterogeneity: Tau <sup>2</sup> =	0.06; 0	$Chi^2 = 4$	40.83, 0	df = 7 (	P < 0.	00001)	$; I^2 = 83\%$		-2 -1 0 1 2			
Test for overall effect:	Z = 2.9	98 (P =	0.003)						fiber [experimental] control [control]			
Test for subgroup diff	erences	: Chi² =	= 1.58,	df = 1	(P = 0)	.21), ľ	= 36.5%					
							(A	)				
		fihar					4	Maan Diffaransa	Maan Difference			
Study or Subgroup	Maan	fiber	Total	C	ontro	 Tota	Waight	Mean Difference	Mean Difference			
Study or Subgroup	Mean	fiber SD	Total	C Mean	Contro SD	l Tota	Weight	Mean Difference IV, Random, 95% CI	Mean Difference IV, Random, 95% Cl			
Study or Subgroup 4.2.1 <16 g	Mean	fiber SD	Total	C Mean	Contro SD	l Tota	Weight	Mean Difference IV, Random, 95% CI	Mean Difference IV, Random, 95% Cl			
<b>Study or Subgroup</b> <b>4.2.1 &lt; 16 g</b> Ahmad, et al 2013	<b>Mean</b> 6.39	fiber SD	<b>Total</b>	<b>Mean</b> 7.61	Contro SD	l Tota	<b>Weight</b>	Mean Difference IV, Random, 95% CI -1.22 [-1.95, -0.49]	Mean Difference IV, Random, 95% Cl			
<b>Study or Subgroup</b> <b>4.2.1 &lt; 16 g</b> Ahmad, et al 2013 Miao, et al 2021	<b>Mean</b> 6.39 0	fiber SD	<b>Total</b>	7.61	<b>SD</b>	I Tota	Weight	Mean Difference IV, Random, 95% Cl -1.22 [-1.95, -0.49] Not estimable	Mean Difference IV, Random, 95% Cl			
<b>Study or Subgroup</b> <b>4.2.1 &lt; 16 g</b> Ahmad, et al 2013 Miao, et al 2021 Pan, et al 2015	<b>Mean</b> 6.39 0 7.14	fiber SD 1 0.52	<b>Total</b> 18 0 48	7.61 7.9	<b>Sontro</b> <b>SD</b> 1.04 0 1.24	I Tota 13 0 48	Weight 5.5%	Mean Difference IV, Random, 95% Cl -1.22 [-1.95, -0.49] Not estimable -0.76 [-1.14, -0.38]	Mean Difference IV, Random, 95% Cl 			
<b>Study or Subgroup</b> <b>4.2.1 &lt; 16 g</b> Ahmad, et al 2013 Miao, et al 2021 Pan, et al 2015 Wu, et al 2020	Mean 6.39 0 7.14 6.13	fiber SD 1 0.52 1.14	<b>Total</b> 18 0 48 42	<b>Mean</b> 7.61 0 7.9 7.19	1.04 0 1.24 1.35	I Tota 13 0 48 42	<b>Weight</b> 5.5% 14.1% 9.0%	Mean Difference IV, Random, 95% Cl -1.22 [-1.95, -0.49] Not estimable -0.76 [-1.14, -0.38] -1.06 [-1.59, -0.53]	Mean Difference IV, Random, 95% Cl 			
<b>Study or Subgroup</b> <b>4.2.1 &lt;16 g</b> Ahmad, et al 2013 Miao, et al 2021 Pan, et al 2015 Wu, et al 2020 Zhang, et al 2021 Subsets (OSE)	Mean 6.39 0 7.14 6.13 6.57	fiber SD 1 0 0.52 1.14 0.67	<b>Total</b> 18 0 48 42 56	<b>Mean</b> 7.61 0 7.9 7.19 7	1.04 0 1.24 1.35 0.51	I Tota 13 0 48 42 56	Weight 5.5% 14.1% 9.0% 22.8%	Mean Difference IV, Random, 95% Cl -1.22 [-1.95, -0.49] Not estimable -0.76 [-1.14, -0.38] -1.06 [-1.59, -0.53] -0.43 [-0.65, -0.21]	Mean Difference IV, Random, 95% CI			
<b>Study or Subgroup</b> <b>4.2.1 &lt; 16 g</b> Ahmad, et al 2013 Miao, et al 2021 Pan, et al 2015 Wu, et al 2020 Zhang, et al 2021 <b>Subtotal (95% CI)</b>	Mean 6.39 0 7.14 6.13 6.57	fiber SD 1 0.52 1.14 0.67	<b>Total</b> 18 0 48 42 56 <b>164</b>	7.61 7.61 7.9 7.19 7	1.04 0 1.24 1.35 0.51	I Tota 13 0 48 42 56 159	Weight 5.5% 14.1% 9.0% 22.8% 51.4%	Mean Difference IV, Random, 95% Cl -1.22 [-1.95, -0.49] Not estimable -0.76 [-1.14, -0.38] -1.06 [-1.59, -0.53] -0.43 [-0.65, -0.21] -0.78 [-1.13, -0.42]	Mean Difference IV, Random, 95% CI			
<b>Study or Subgroup</b> <b>4.2.1 &lt; 16 g</b> Ahmad, et al 2013 Miao, et al 2021 Pan, et al 2025 Wu, et al 2020 Zhang, et al 2021 <b>Subtotal (95% CI)</b> Heterogeneity: Tau <sup>2</sup> =	Mean 6.39 0 7.14 6.13 6.57 = 0.08;	fiber SD 1 0.52 1.14 0.67 Chi <sup>2</sup> =	<b>Total</b> 18 0 48 42 56 <b>164</b> 8.56, c	<b>C</b> Mean 7.61 0 7.9 7.19 7 .19 7	1.04 0 1.24 1.35 0.51 P = 0.	l Tota 13 0 48 42 56 159 04); l <sup>2</sup>	Weight 5.5% 14.1% 9.0% 22.8% 51.4% = 65%	Mean Difference IV, Random, 95% Cl -1.22 [-1.95, -0.49] Not estimable -0.76 [-1.14, -0.38] -1.06 [-1.59, -0.53] -0.43 [-0.65, -0.21] -0.78 [-1.13, -0.42]	Mean Difference IV, Random, 95% CI			
Study or Subgroup 4.2.1 < 16 g Ahmad, et al 2013 Miao, et al 2021 Pan, et al 2025 Wu, et al 2020 Zhang, et al 2021 Subtotal (95% CI) Heterogeneity: Tau <sup>2</sup> = Test for overall effect	Mean 6.39 0 7.14 6.13 6.57 = 0.08; ; Z = 4.	fiber SD 1 0.52 1.14 0.67 Chi <sup>2</sup> = 27 (P -	<b>Total</b> 18 0 48 42 56 <b>164</b> 8.56, c < 0.000	C Mean 7.61 0 7.9 7.19 7.19 7 (If = 3 ( 91)	1.04 0 1.24 1.35 0.51 P = 0.	l Tota 13 0 48 42 56 159 04); I <sup>2</sup>	Weight           5.5%           14.1%           9.0%           22.8%           51.4%           65%	Mean Difference IV, Random, 95% CI -1.22 [-1.95, -0.49] Not estimable -0.76 [-1.14, -0.38] -1.06 [-1.59, -0.53] -0.43 [-0.65, -0.21] -0.78 [-1.13, -0.42]	Mean Difference IV, Random, 95% CI			
Study or Subgroup 4.2.1 < 16 g Ahmad, et al 2013 Miao, et al 2021 Pan, et al 2025 Wu, et al 2020 Zhang, et al 2021 Subtotal (95% CI) Heterogeneity: Tau <sup>2</sup> = Test for overall effect	Mean 6.39 0 7.14 6.13 6.57 = 0.08; ; Z = 4.	fiber SD 1 0.52 1.14 0.67 Chi <sup>2</sup> = 27 (P -	<b>Total</b> 18 0 48 42 56 <b>164</b> 8.56, c < 0.000	C Mean 7.61 0 7.9 7.19 7.19 7 11 11	1.04 0 1.24 1.35 0.51 P = 0.	l Tota 13 0 48 42 56 159 04); l <sup>2</sup>	Weight 5.5% 14.1% 9.0% 22.8% 51.4% = 65%	Mean Difference IV, Random, 95% Cl -1.22 [-1.95, -0.49] Not estimable -0.76 [-1.14, -0.38] -1.06 [-1.59, -0.53] -0.43 [-0.65, -0.21] -0.78 [-1.13, -0.42]	Mean Difference IV, Random, 95% CI			
Study or Subgroup 4.2.1 < 16 g Ahmad, et al 2013 Miao, et al 2021 Pan, et al 2025 Wu, et al 2020 Zhang, et al 2021 Subtotal (95% CI) Heterogeneity: Tau <sup>2</sup> = Test for overall effect 4.2.2 $\geq$ 16 g	Mean 6.39 0 7.14 6.13 6.57 = 0.08; ; Z = 4.	fiber SD 1 0.52 1.14 0.67 Chi <sup>2</sup> = 27 (P	<b>Total</b> 18 0 48 42 56 <b>164</b> 8.56, c < 0.000	C Mean 7.61 0 7.9 7.19 7 7.19 7 19 7 19 7	1.04 0 1.24 1.35 0.51 P = 0.	l Tota 13 0 48 42 56 159 04); l <sup>2</sup>	Weight 5.5% 14.1% 9.0% 22.8% 51.4% = 65%	Mean Difference IV, Random, 95% Cl -1.22 [-1.95, -0.49] Not estimable -0.76 [-1.14, -0.38] -1.06 [-1.59, -0.53] -0.43 [-0.65, -0.21] -0.78 [-1.13, -0.42]	Mean Difference IV, Random, 95% CI			
Study or Subgroup 4.2.1 <16 g Ahmad, et al 2013 Miao, et al 2021 Pan, et al 2020 Zhang, et al 2020 Zhang, et al 2020 Subtotal (95% CI) Heterogeneity: Tau <sup>2</sup> = Test for overall effect 4.2.2 $\geq$ 16 g Deng, et al 2019	Mean 6.39 0 7.14 6.13 6.57 = 0.08; ; Z = 4. 6.1	fiber SD 1 0.52 1.14 0.67 Chi <sup>2</sup> = 27 (P -	<b>Total</b> 18 0 48 42 56 <b>164</b> 8.56, c < 0.000 51	C Mean 7.61 0 7.9 7.19 7 19 7 19 7 19 7 7 19 7 7 19 7 7	1.04 0 1.24 1.35 0.51 P = 0.	I Tota 13 0 48 42 56 159 04); I <sup>2</sup>	Weight 5.5% 14.1% 9.0% 22.8% 51.4% = 65%	Mean Difference IV, Random, 95% Cl -1.22 [-1.95, -0.49] Not estimable -0.76 [-1.14, -0.38] -1.06 [-1.59, -0.53] -0.43 [-0.65, -0.21] -0.78 [-1.13, -0.42]	Mean Difference IV, Random, 95% CI			
Study or Subgroup 4.2.1 <16 g Ahmad, et al 2013 Miao, et al 2021 Pan, et al 2025 Wu, et al 2020 Zhang, et al 2020 Zhang, et al 2021 Subtotal (95% CI) Heterogeneity: Tau <sup>2</sup> = Test for overall effect 4.2.2 $\geq$ 16 g Deng, et al 2019 Wang, et al 2021	Mean 6.39 0 7.14 6.13 6.57 = 0.08; : Z = 4. 6.1 5.72	fiber SD 1 0.52 1.14 0.67 Chi <sup>2</sup> = 27 (P 1.57 0.83	<b>Total</b> 18 0 48 42 56 <b>164</b> 8.56, c < 0.000 51 60	C Mean 7.61 0 7.19 7.19 7.19 7.19 7.19 7.19 7.19 7.02 6.19	1.04 0 1.24 1.35 0.51 P = 0. 1.76 0.93	I Tota 13 0 48 42 56 159 04); I <sup>2</sup>	Weight 5.5% 14.1% 9.0% 22.8% 51.4% = 65% 6.6% 17.2%	Mean Difference IV, Random, 95% Cl -1.22 [-1.95, -0.49] Not estimable -0.76 [-1.14, -0.38] -1.06 [-1.59, -0.53] -0.43 [-0.65, -0.21] -0.78 [-1.13, -0.42]	Mean Difference IV, Random, 95% CI			
Study or Subgroup 4.2.1 <16 g Ahmad, et al 2013 Miao, et al 2021 Pan, et al 2020 Zhang, et al 2020 Zhang, et al 2021 Subtotal (95% Cl) Heterogeneity: Tau <sup>2</sup> = Test for overall effect 4.2.2 $\geq$ 16 g Deng, et al 2021 Zahra, et al 2021 Zahra, et al 2021 Zahra, et al 2021	Mean 6.39 0 7.14 6.13 6.57 = 0.08; ; Z = 4. 6.1 5.72 5.78	fiber SD 1 0.52 1.14 0.67 Chi <sup>2</sup> = 27 (P 1.57 0.83 0.3	<b>Total</b> 18 0 48 42 56 <b>164</b> 8.56, c < 0.000 51 60 53 53	C Mean 7.61 0 7.9 7.19 7 7 8f = 3 ( 91) 7.02 6.19 6.53	1.04 0 1.24 1.35 0.51 P = 0. 1.76 0.93 0.63	I Tota 13 (0 48 42 56 159 04); I <sup>2</sup>	Weight 5.5% 14.1% 9.0% 22.8% 51.4% 51.4% 51.4% 51.4% 51.4% 51.4% 51.4%	Mean Difference IV, Random, 95% Cl -1.22 [-1.95, -0.49] Not estimable -0.76 [-1.14, -0.38] -1.06 [-1.59, -0.53] -0.43 [-0.65, -0.21] -0.78 [-1.13, -0.42] -0.92 [-1.57, -0.27] -0.47 [-0.79, -0.15] -0.75 [-0.94, -0.56]	Mean Difference IV, Random, 95% CI			
<b>Study or Subgroup</b> <b>4.2.1 &lt; 16 g</b> Ahmad, et al 2013 Miao, et al 2021 Pan, et al 2020 Zhang, et al 2020 Zhang, et al 2020 <b>Subtotal (95% CI)</b> Heterogeneity: Tau <sup>2</sup> = Test for overall effect <b>4.2.2 <math>\geq</math> 16 g</b> Deng, et al 2021 Zahra, et al 2021 Zahra, et al 2021 <b>Subtotal (95% CI)</b>	Mean 6.39 0 7.14 6.13 6.57 = 0.08; : Z = 4. 6.1 5.72 5.78	fiber SD 1 0.52 1.14 0.67 Chi <sup>2</sup> = 27 (P - 1.57 0.83 0.3	<b>Total</b> 18 0 48 42 56 <b>164</b> 8.56, c < 0.0000 51 60 53 <b>164</b>	C           Mean           7.61           0           7.9           7           1f = 3 (           7           01           7.02           6.19           6.53	1.04 0 1.24 1.35 0.51 P = 0. 1.76 0.93 0.63	l Tota 13 0 48 42 56 159 04); l <sup>2</sup> 49 60 51	<pre>Weight 5.5% 14.1% 9.0% 22.8% 51.4% 65% 6.6% 17.2% 24.8% 48.6%</pre>	Mean Difference IV, Random, 95% CI           -1.22 [-1.95, -0.49] Not estimable           -0.76 [-1.14, -0.38]           -1.06 [-1.59, -0.53]           -0.43 [-0.65, -0.21]           -0.78 [-1.13, -0.42]           -0.78 [-1.13, -0.42]           -0.75 [-0.94, -0.56]           -0.75 [-0.94, -0.56]           -0.68 [-0.89, -0.47]	Mean Difference IV, Random, 95% CI			
Study or Subgroup 4.2.1 <16 g Ahmad, et al 2013 Miao, et al 2021 Pan, et al 2020 Zhang, et al 2020 Zhang, et al 2021 Subtotal (95% CI) Heterogeneity: Tau <sup>2</sup> = Test for overall effect 4.2.2 $\geq$ 16 g Deng, et al 2021 Zahra, et al 2021 Subtotal (95% CI) Heterogeneity: Tau <sup>2</sup> =	Mean 6.39 0 7.14 6.13 6.57 = 0.08; : Z = 4. 6.1 5.72 5.78 = 0.01;	fiber SD 1 0 0.52 1.14 0.67 Chi <sup>2</sup> = 27 (P 1.57 0.83 0.3 Chi <sup>2</sup> =	<b>Total</b> 18 0 48 42 56 <b>164</b> 8.56, c < 0.000 51 60 53 <b>164</b> 2.72, c	C           Mean           7.61           0           7.9           7           1f = 3 (           1)           7.02           6.19           6.53           lf = 2 (	$\begin{array}{c} \text{Contromediate} \\ \text{SD} \\ 1.04 \\ 0 \\ 1.24 \\ 1.35 \\ 0.51 \\ \text{P} = 0. \\ 1.76 \\ 0.93 \\ 0.63 \\ \text{P} = 0. \end{array}$	l Tota 13 0 48 42 56 159 04); l <sup>2</sup> 49 60 51 160 26); l <sup>2</sup>	<pre>Weight 5.5% 14.1% 9.0% 22.8% 51.4% 65% 6.6% 17.2% 24.8% 48.6% 27%</pre>	Mean Difference IV, Random, 95% Cl -1.22 [-1.95, -0.49] Not estimable -0.76 [-1.14, -0.38] -1.06 [-1.59, -0.53] -0.43 [-0.65, -0.21] -0.78 [-1.13, -0.42] -0.92 [-1.57, -0.27] -0.47 [-0.79, -0.15] -0.75 [-0.94, -0.56] -0.68 [-0.89, -0.47]	Mean Difference IV, Random, 95% CI			
Study or Subgroup 4.2.1 <16 g Ahmad, et al 2013 Miao, et al 2021 Pan, et al 2020 Zhang, et al 2020 Zhang, et al 2021 Subtotal (95% Cl) Heterogeneity: Tau <sup>2</sup> = Test for overall effect 4.2.2 $\geq$ 16 g Deng, et al 2021 Zahra, et al 2021 Zahra, et al 2021 Subtotal (95% Cl) Heterogeneity: Tau <sup>2</sup> = Test for overall effect	Mean 6.39 0 7.14 6.13 6.57 = 0.08; : Z = 4. 6.1 5.72 5.78 = 0.01; : Z = 6.	fiber SD 1 0 0.52 1.14 0.67 Chi <sup>2</sup> = 27 (P 1.57 0.83 0.3 Chi <sup>2</sup> = 29 (P	<b>Total</b> 18 0 48 42 56 <b>164</b> 8.56, c < 0.000 51 60 53 <b>164</b> 2.72, c < 0.000	C           Mean           7.61           0           7.9           7           9           7.19           7           1f = 3 (           7.02           6.19           6.53           8f = 2 (           901)	Contro         SD           1.04         0           1.24         1.35           0.51         0.51           1.76         0.93           0.63         P = 0.	l Tota 13 0 48 42 56 159 04); l <sup>2</sup> 49 60 51 160 26); l <sup>2</sup>	<pre>Weight 5.5% 14.1% 9.0% 22.8% 51.4% 65% 6.6% 17.2% 24.8% 48.6% 27%</pre>	Mean Difference IV, Random, 95% Cl -1.22 [-1.95, -0.49] Not estimable -0.76 [-1.14, -0.38] -1.06 [-1.59, -0.53] -0.43 [-0.65, -0.21] -0.78 [-1.13, -0.42] -0.78 [-1.13, -0.42] -0.75 [-0.94, -0.56] -0.68 [-0.89, -0.47]	Mean Difference IV, Random, 95% CI			
Study or Subgroup 4.2.1 <16 g Ahmad, et al 2013 Miao, et al 2021 Pan, et al 2020 Zhang, et al 2020 Zhang, et al 2021 Subtotal (95% Cl) Heterogeneity: Tau <sup>2</sup> = Test for overall effect 4.2.2 $\geq$ 16 g Deng, et al 2021 Zahra, et al 2021 Zahra, et al 2021 Subtotal (95% Cl) Heterogeneity: Tau <sup>2</sup> = Test for overall effect Test for overall effect	Mean 6.39 0 7.14 6.13 6.57 = 0.08; : Z = 4. 6.1 5.72 5.78 = 0.01; : Z = 6.	fiber SD 1 0.52 1.14 0.67 Chi <sup>2</sup> = 27 (P 1.57 0.83 0.3 Chi <sup>2</sup> = 29 (P	<b>Total</b> 18 0 48 42 56 <b>164</b> 8.56, c < 0.000 51 60 53 <b>164</b> 2.72, c < 0.000	7.61 0 7.9 7.19 7 1f = 3 ( 1) 7.02 6.19 6.53 df = 2 ( 001)	Contro         SD           1.04         0           0.124         1.35           0.51         0.51           1.76         0.93           0.63         P = 0.	l Tota 13 0 48 42 56 159 04); l <sup>2</sup> 49 60 51 160 26); l <sup>2</sup>	<pre>Weight 5.5% 14.1% 9.0% 22.8% 51.4% 65% 6.6% 17.2% 24.8% 48.6% 24.8% 48.6% 27%</pre>	Mean Difference IV, Random, 95% CI -1.22 [-1.95, -0.49] Not estimable -0.76 [-1.14, -0.38] -1.06 [-1.59, -0.53] -0.43 [-0.65, -0.21] -0.78 [-1.13, -0.42] -0.78 [-1.13, -0.42] -0.47 [-0.79, -0.15] -0.47 [-0.79, -0.15] -0.58 [-0.89, -0.47]	Mean Difference IV, Random, 95% CI			
Study or Subgroup 4.2.1 <16 g Ahmad, et al 2013 Miao, et al 2021 Pan, et al 2020 Zhang, et al 2020 Zhang, et al 2021 Subtotal (95% CI) Heterogeneity: Tau <sup>2</sup> = Test for overall effect 4.2.2 $\geq$ 16 g Deng, et al 2021 Zahra, et al 2021 Zabtotal (95% CI) Heterogeneity: Tau <sup>2</sup> = Test for overall effect	Mean 6.39 0 7.14 6.13 6.57 = 0.08; z = 4. 6.1 5.72 5.78 = 0.01; z = 6.	fiber SD 1 0.52 1.14 0.67 Chi <sup>2</sup> = 27 (P - 1.57 0.83 0.3 Chi <sup>2</sup> = 29 (P -	Total 18 0 48 42 56 164 8.56, c < 0.000 51 60 53 164 2.72, c < 0.000 328	7.61 0 7.9 7.19 7 8f = 3 ( 11) 7.02 6.19 6.53 8f = 2 ( 001)	Contro         SD           1.04         0           0         1.24           1.35         0.51           P = 0.         0.63           0.63         P = 0.	l Tota 13 0 48 42 56 159 04); l <sup>2</sup> 49 61 160 26); l <sup>2</sup> 319	<pre>Weight 5.5% 14.1% 9.0% 22.8% 51.4% 65% 6.6% 17.2% 24.8% 48.6% 24.8% 48.6% 27% 100.0%</pre>	Mean Difference IV, Random, 95% Cl -1.22 [-1.95, -0.49] Not estimable -0.76 [-1.14, -0.38] -1.06 [-1.59, -0.53] -0.43 [-0.65, -0.21] -0.78 [-1.13, -0.42] -0.78 [-1.13, -0.42] -0.75 [-0.94, -0.56] -0.68 [-0.89, -0.47] -0.70 [-0.88, -0.51]	Mean Difference IV, Random, 95% CI			
Study or Subgroup 4.2.1 < 16 g Ahmad, et al 2013 Miao, et al 2021 Pan, et al 2025 Wu, et al 2020 Zhang, et al 2021 Subtotal (95% CI) Heterogeneity: Tau <sup>2</sup> = Test for overall effect 4.2.2 $\geq$ 16 g Deng, et al 2021 Zahra, et al 2021 Zahra, et al 2021 Subtotal (95% CI) Heterogeneity: Tau <sup>2</sup> = Test for overall effect Total (95% CI) Heterogeneity: Tau <sup>2</sup> =	Mean 6.39 0 7.14 6.13 6.57 = 0.08; Z = 4. 6.1 5.72 5.78 = 0.01; Z = 6. = 0.03;	fiber SD 1 0 0.52 1.14 0.67 Chi <sup>2</sup> = 27 (P - 1.57 0.83 0.3 Chi <sup>2</sup> = 29 (P - Chi <sup>2</sup> =	Total 18 0 48 42 56 164 8.56, c < 0.000 51 60 53 164 2.72, c < 0.000 328 11.70,	C           Mean           7.61           0           7.9           7.19           7           df = 3 (           7.02           6.19           6.53           df = 2 (           001)           df = 6	Contro         SD           1.04         0           0         1.24           1.35         0.51           P         0           1.766         0.93           0.633         P           0.63         P           (P         (	l Tota 13 0 48 42 56 159 04); l <sup>2</sup> 49 60 51 160 26); l <sup>2</sup> 319 0.07); l	<pre>Weight     5.5%     14.1%     9.0%     22.8%     51.4%     65%     6.6%     17.2%     24.8%     48.6%     27%     100.0%     2 = 49%</pre>	Mean Difference IV, Random, 95% CI           -1.22 [-1.95, -0.49] Not estimable           -0.76 [-1.14, -0.38]           -1.06 [-1.59, -0.53]           -0.43 [-0.65, -0.21]           -0.78 [-1.13, -0.42]           -0.78 [-1.13, -0.42]           -0.76 [-0.94, -0.56]           -0.68 [-0.89, -0.47]	Mean Difference IV, Random, 95% CI			
Study or Subgroup 4.2.1 < 16 g Ahmad, et al 2013 Miao, et al 2021 Pan, et al 2025 Wu, et al 2020 Zhang, et al 2021 Subtotal (95% CI) Heterogeneity: Tau <sup>2</sup> = Test for overall effect 4.2.2 $\geq$ 16 g Deng, et al 2021 Zahra, et al 2021 Zahra, et al 2021 Subtotal (95% CI) Heterogeneity: Tau <sup>2</sup> = Test for overall effect Total (95% CI) Heterogeneity: Tau <sup>2</sup> = Test for overall effect	Mean 6.39 0 7.14 6.13 6.57 = 0.08; Z = 4. 6.1 5.72 5.78 = 0.01; Z = 6. = 0.03; Z = 7.	fiber SD 1 0 0.52 1.14 0.67 Chi <sup>2</sup> = 27 (P - 1.57 0.83 0.3 Chi <sup>2</sup> = 29 (P - Chi <sup>2</sup> = 29 (P - Chi <sup>2</sup> = 29 (P - Chi <sup>2</sup> = 27 (P - Chi <sup>2</sup> = 29 (P - Chi <sup>2</sup> = 27 (P - Chi <sup>2</sup> = 29 (P - Chi <sup>2</sup> = 27 (P - Chi <sup>2</sup> = 29 (P - Chi <sup>2</sup> = 29 (P - Chi <sup>2</sup> = 29 (P - Chi <sup>2</sup> = 29 (P - Chi <sup>2</sup> = 20 (P -	Total 18 0 48 42 56 164 8.56, c < 0.000 51 60 53 164 2.72, c < 0.000 328 11.70, < 0.000	C Mean 7.61 0 7.9 7.9 7 1f = 3 ( 1) 7.02 6.19 6.53 df = 2 ( 001) df = 6 001)	Contro         SD           1.04         0           0         1.24           1.35         0.51           P         0           1.766         0.93           0.633         P           0         (P           (P         (P	l Total 13 0 48 42 56 159 04); l <sup>2</sup> 49 61 51 160 26); l <sup>2</sup> 319 0.07); l		Mean Difference IV, Random, 95% Cl -1.22 [-1.95, -0.49] Not estimable -0.76 [-1.14, -0.38] -1.06 [-1.59, -0.53] -0.43 [-0.65, -0.21] -0.78 [-1.13, -0.42] -0.78 [-1.13, -0.42] -0.75 [-0.94, -0.56] -0.68 [-0.89, -0.47] -0.70 [-0.88, -0.51]	Mean Difference IV, Random, 95% CI			

(B)

**Figure 7.** Forest plots of subgroup analysis of fiber quantity on (**A**) fasting glucose (mmol/L) and (**B**) 2-h glucose (mmol/L) [14–21].





**Figure 8.** Forest plots of subgroup analysis of fiber quantity on (**A**) Total cholesterol (TC, mmol/L) and (**B**) Triglycerides (TG, mmol/L) [15,16,18,20].

# 3.10. Sensitivity Analyses and Publication Bias

Funnel plots (Figure 10) were used to qualitatively evaluate publication bias and Egger's test was used to quantitatively determine publication bias. The results showed no significant publication bias for fasting glucose (t = -1.11, p = 0.311) and two-hour postprandial glucose (t = 0.45, p = 0.671).

Subtotal (95% CI)

Total events

5.11.2 ≥12 g

Total events

Total (95% CI)

Total events

DENG Y P, et al 2019

Heterogeneity: Not applicable

Subtotal (95% CI)

	fibe	r	Cont	rol		Odds Ratio	Odds Ratio
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Random, 95% CI	M-H, Random, 95% CI
5.9.1 <12 g							
Fang Pan, et al 2015	2	48	4	48	18.2%	0.48 [0.08, 2.74]	
ZHANG Zhuangwei, et al 2021	6	56	9	56	45.3%	0.63 [0.21, 1.90]	
Subtotal (95% CI)		104		104	63.6%	0.58 [0.23, 1.48]	$\bullet$
Total events	8		13				
Heterogeneity: $Tau^2 = 0.00$ ; $Chi^2$	= 0.07,	df = 1	(P = 0.8)	0); $I^2 =$	0%		
Test for overall effect: $Z = 1.14$ (	P = 0.25	)					
5 0 2 > 12 a							
$5.5.2 \ge 12$ y	4	F 1	10	40	26 40/	0 22 [0 10 1 14]	
Subtotal (95% CI)	4	51 51	10	49 49	36.4%	0.33 [0.10, 1.14]	
Total events	4	51	10		5011/0	0.55 [0.10, 111.]	
Heterogeneity: Not applicable	4		10				
Test for overall effect: $Z = 1.75$ (	P = 0.08	)					
		,					
Total (95% CI)		155		153	100.0%	0.47 [0.22, 1.00]	$\bullet$
Total events	12		23	2			
Heterogeneity: $Tau^2 = 0.00$ ; Chi <sup>2</sup>	= 0.56,	df = 2	(P = 0.7)	5); I <sup>2</sup> =	0%		0.002 0.1 1 10 500
Test for overall effect: $Z = 1.97$ (i)	P = 0.05	) )	1 (0 0	4 (2) 12	0%		fiber [experimental] control [control]
rest for subgroup differences. Ch	11 = 0.50	), ui =	I(P = 0	.40), 1	= 0%		
					(	(A)	
	fibe	r	Cont	rol		Odds Ratio	Odds Ratio
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Random, 95% CI	M–H, Random, 95% Cl
5.10.1 <12 g							
ZHANG Zhuangwei,et al 2021	24	56	31	56	41.4%	0.60 [0.29, 1.28]	
Subtotal (95% CI)		56		56	41.4%	0.60 [0.29, 1.28]	◆
Total events	24		31				
Heterogeneity: Not applicable							
Test for overall effect: $Z = 1.32$ (	P = 0.19	)					
5.10.2 ≥12 g							
DENG Y P, et al 2019	10	51	18	49	28.3%	0.42 [0.17, 1.04]	
WU lunging, et al 2020	16	42	18	42	30.3%	0.82 [0.34, 1.96]	<b>_</b>
Subtotal (95% CI)		93		91	58.6%	0.59 [0.31, 1.14]	$\bullet$
Total events	26		36				
Heterogeneity: $Tau^2 = 0.02$ ; $Chi^2$	= 1.09,	df = 1	(P = 0.3)	0); $I^2 =$	8%		
Test for overall effect: $Z = 1.56$ (	P = 0.12	)					
Total (95% CI)		149		147	100.0%	0.60 [0.37. 0.97]	•
Total events	50		67				•
Heterogeneity: $Tau^2 = 0.00$ ; Chi <sup>2</sup>	= 1.09.	df = 2	(P = 0.5)	8): $I^2 =$	0%		
Test for overall effect: $Z = 2.10$ (	P = 0.04	)	(	-,, .	•,•		0.005 0.1 1 10 200
Test for subgroup differences: Ch	$i^2 = 0.00$	), df =	1 (P = 0)	97), l <sup>2</sup>	= 0%		liber [experimental] control [control]
					(F	3)	
	files		Cort		(1	Odds Patio	Odde Patio
Study or Subaroup	Events	Total	Evente	Total	Weight	M-H. Random, 95% CI	M-H. Random 95% CI
5.11.1 <12 a	LVCIILS	iotal	LVCIILS	Total	weight	m-n, Kanuoni, 55% Cl	
Fang Pan, et al 2015	6	48	14	48	37 2%	0.35 [0.12 1.00]	<b>_</b>
ZHANG Zhuangwei, et al 2021	5	56	8	56	29.6%	0.59 [0.18, 1.92]	
Subtotal (95% CI)	5	104	0	104	66.8%	0.44 [0.20, 0.97]	

(C)

51 **51** 

155

11

5

5

16

Heterogeneity: Tau<sup>2</sup> = 0.00; Chi<sup>2</sup> = 0.71, df = 2 (P = 0.70); I<sup>2</sup> = 0%

Test for subgroup differences:  $Chi^2 = 0.29$ , df = 1 (P = 0.59),  $I^2 = 0\%$ 

Heterogeneity: Tau<sup>2</sup> = 0.00; Chi<sup>2</sup> = 0.42, df = 1 (P = 0.51); I<sup>2</sup> = 0%

Test for overall effect: Z = 2.05 (P = 0.04)

Test for overall effect: Z = 2.10 (P = 0.04)

Test for overall effect: Z = 2.88 (P = 0.004)

49

49

33.2%

33.2%

153 100.0%

22

13

13

35

0.01

0.1

10

i

fiber [experimental] control [control]

100

0.44 [0.20, 0.97]

0.30 [0.10, 0.92]

0.30 [0.10, 0.92]

0.39 [0.20, 0.74]

Figure 9. Forest plots of subgroup analysis of fiber quantity on (A) preterm deliveries, (B) cesarean deliveries, and (C) macrosomia [15–17,21].



Figure 10. Funnel plot of publication bias for the primary outcomes.

# 4. Discussion

In general, dietary fiber is the edible part of plants, or similar carbohydrates, which resist digestion and absorption in the intestine. Dietary fiber can be divided into many different fractions, including arabinoxylan, inulin, pectin, bran, cellulose, beta-glucan, and resistant starch. The mechanisms of the metabolic health effects of dietary fiber may be related to changes in intestinal viscosity, nutrient absorption, rate of transmission, short-chain fatty acid production, and intestinal hormone production [22]. Chinese women are part of the international high-risk group for gestational diabetes mellitus (GDM), and a meta-analysis of Chinese women with GDM showed that a low-GI diet, a low-GL diet, and a fiber-rich diet were associated with improved glycemic control and pregnancy outcomes [23]. A dietary pattern with more rice, beans, and vegetables and fewer full-fat dairy products, cookies, and sweets had a higher fiber density and were negatively associated with thrombosis index and gestational diabetes [24].

#### 4.1. Effects of Fiber-Fortified Food on Serum Glucose Outcomes

Dietary fiber plays an important role in the control of postprandial glucose and insulin response in diabetic patients. Dietary fiber intake has been shown to slow gastric emptying in healthy subjects, and similarly, the effect of soluble dietary fiber in improving postprandial glucose in patients with type 2 diabetes is associated with slower gastric emptying [25]. During a short-term intervention, increased intake of soluble dietary fiber significantly improved blood glucose levels, insulin resistance, and metabolic profiles in diabetic patients, but not islet secretion [26]. Insoluble oat fiber can also effectively affect blood glucose metabolism, with the most pronounced effect in subjects with impaired fasting glucose, even alone [27]. Different types of dietary fiber may differ in carbohydrate uptake and metabolism [28]. In China, results of a prospective analysis of the association between dietary fiber intake and the risk of developing prediabetes in Chinese adults showed that fiber from fruits, but not from grains, legumes, and vegetables, was negatively associated with prediabetes. Intake of total dietary fiber, soluble fiber, and fiber from fruits was associated with a lower risk of prediabetes [29]. The traditional view is that viscosity and solubility are the main reasons why dietary fiber improves blood glucose. However, a study used enzymatic extraction of barley insoluble fiber (BIF) and soluble fiber (BSF) to compare the anti-diabetic effects and found that both had hypoglycemic lipidemic effects but may act through different mechanisms in the intestinal flora [30]. The results of our meta-analysis showed that additional dietary fiber fortification significantly improved fasting and postprandial glucose and glycated hemoglobin in patients with gestational diabetes, and that insoluble dietary fiber may be more effective in improving fasting glucose, similar to the results of Kabisch's study [27], suggesting that there are other reasons beyond viscosity and solubility that influence the glycemic improvement of different types of dietary fiber. Consuming foods high in dietary fiber may help prevent diabetes. Studies

have shown that in the general Japanese population, a higher intake of dietary fiber is associated with a lower risk of developing type 2 diabetes [31]. A prospective cohort study of dietary fiber intake and risk of Type 2 Diabetes showed a non-linear relationship between total dietary fiber intake and risk of Type 2 Diabetes [32]. The results of this meta-analysis showed that dietary fiber fortification with  $\geq 12$  g/day was more effective in improving fasting blood glucose than <12 g/day, and there was no significant difference in two-hour postprandial blood glucose.

#### 4.2. Effects of Fiber-Fortified Food on Lipid Metabolism

The role of dietary fiber in regulating lipid metabolism has been confirmed by numerous studies. Consumption of soluble fiber can reduce cholesterol and LDL levels by about 5–10%, but changes in HDL or triglyceride levels are minimal, and high molecular weight fiber is more effective in reducing lipid levels [33]. The lipid-lowering effect of fiber may be related to its viscosity, the higher the viscosity of fiber, the better the lipid-lowering effect [34]. However, the results of a study evaluating the relationship between dietary fiber sources and cardiovascular risk factors in a Spanish population showed that higher insoluble fiber intake has an important role in the control and management of hypertension, blood lipids, and methionine [35]. Since there was only one article in at least one subgroup in this study, the effect of fiber type on lipids was not included in the analysis, and more studies are needed to discuss it. Dietary fiber intake also has an effect on blood lipids. In diabetic patients, a decrease in dietary fiber intake was positively associated with cholesterol and LDL levels [36]. In addition, pre-pregnancy dietary patterns were also associated with gestational lipid levels, with higher fast food and candy pattern scores associated with higher triglyceride levels and slower HDL-C changes during pregnancy, while higher vegetable and dairy dietary pattern scores were associated with faster HDL-C changes during pregnancy [37]. The results of this study showed that higher fiber intake may be more effective in lowering blood lipids, but the difference between the two groups was not statistically significant, and it is possible that the additional dietary fiber fortification in both groups far exceeded the recommended intake, and confounding factors such as diet need to be excluded.

# 4.3. Effects of Fiber-Fortified Food on Pregnancy and Neonatal Outcome

Dietary interventions in early pregnancy have a positive impact on maternal gastrointestinal index, nutrient intake, and weight gain during pregnancy. Increased dietary fiber intake may prevent excessive maternal weight gain and reduce infant birth weight [38]. Pre-pregnancy dietary patterns were also associated with neonatal outcomes, with a higher intake of fast food and sweets increasing the rate of large births, while vegetable and dairy dietary patterns reduced the chances of preterm birth [39]. Processed diets high in fat and low in fiber reduce gut microbiota alpha diversity thus affecting spontaneous preterm birth (SPTB) [40]. Our study showed similar results. Dietary fiber reduced the incidence of preterm delivery, cesarean delivery, and fetal distress, and also significantly decreased neonatal weight. Higher fiber intake may have a better effect on pregnancy and neonatal outcomes, but the difference between the two groups was not statistically significant. There was only one article on at least one subgroup type, for this reason, the effect of fiber type on blood lipids was not included in the analysis, and more studies are needed to discuss it.

#### 4.4. Strengths, Limitations, and Insights

This article reviewed the beneficial improvements of fiber fortification in pregnant women with gestational diabetes, not just fiber in the general diet. The different benefits of different fiber types and doses were also highlighted. This provides valuable insights into the management of glycemic control in pregnant women.

Due to the low number of articles included in this meta-analysis, the publication bias derived from the funnel plot may not be conclusive, and more experiments are needed to further prove our point in the future.

# 5. Conclusions

In conclusion, evidence from our meta-analysis suggested that additional dietary fiber supplementation significantly reduced fasting and two-hour postprandial glucose in people with gestational diabetes. In addition, it also assisted in reducing lipid levels and improving adverse pregnancy and neonatal outcomes. However, there are some limitations in this review, so further high-quality and large-sample-size studies are needed to validate the effects of different fiber types and doses on outcomes.

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