

**Table E.1.4.c. People with Type 2 Diabetes, relationship between physical activity and health-related outcomes**

**Questions:** What is the association between **physical activity** and health-related outcomes? Is there a dose response association (volume, duration, frequency, intensity)? Does the association vary by type or domain of PA?

**Population:** People with Type 2 Diabetes

**Exposure:** Greater volume, duration, frequency, or intensity of physical activity

**Comparison:** No physical activity or lesser volume, duration, frequency, or intensity of physical activity

**Outcome:** Risk of co-morbid conditions, physical function, health-related QOL, disease progression

Systematic review evidence	No. of studies/ Study design	Quality Assessment					Description of evidence Summary of findings	Certainty	US PAGAC evidence (39)
		Risk of bias	Inconsistency	Indirectness†	Imprecision	Other			
<b>Risk of co-morbid conditions</b>									
Lauche 2017 (15) Moderate	0 RCTs	NA	NA	NA	NA	NA	No trials were identified that examined the effects of Tai Chi/qigong on stroke incidence among those with diabetes.	NA	<a href="#">3 ESRs</a> Strong evidence demonstrates an inverse association between volume of physical activity and risk of cardiovascular mortality among adults with type 2 diabetes. <b>PAGAC Grade: Strong.</b>
<b>Physical function</b>									
Zhou 2019 (36) Moderate	2 RCTs N=NR	No serious risk of bias	No serious inconsistency	Serious indirectness	Serious imprecision	None	Studies evaluated <b>Tai Chi</b> among adults with T2D, mean age range 36 to 70 years. Mean sessions of exercise ranged from 15 to 120 min with 2 to 14 sessions per week. Total intervention duration ranged from 4 to 24 weeks.  There were no effects of Tai Chi on measures of <b>balance</b> compared with controls (MD = 2.17 secs [single-leg stance] [95% CI, -3.29 to 8.71], 2 RCTs).	LOW <sup>b</sup>	<a href="#">1 ESR</a> Insufficient evidence was available to determine the relationship between physical activity and physical function in adults with type 2 diabetes. <b>PAGAC Grade: Not assignable.</b>

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		Risk of bias	Inconsistency	Indirectness	Imprecision	Other			
Review credibility	No. of participants						Summary of findings		
<b>Health-related QOL</b>									
Rees 2017 (27) Moderate	2 pre-post N=40	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None	Studies evaluated effect of <b>aquatic exercise</b> vs. land-based exercises or no-exercise control groups. No significant differences was found before and after aquatic exercise for the physical function domain (SMD = 0.08 [95% CI, -2.80 to 2.96], 2 studies, n=40) or mental health domain (SMD = -0.36 [95% CI, -2.85 to 2.12], 2 studies, n=40) of the SF-36 or SF-12 forms.	LOW <sup>c</sup>	<a href="#">6 ESRs</a> Insufficient evidence was available to determine the relationship between physical activity and health-related quality of life in adults with type 2 diabetes. <b>PAGAC Grade: Not assignable.</b>
Yu 2018 (34) Moderate	6 RCTs N=NR	Serious risk of bias	No serious inconsistency	No serious indirectness	Serious imprecision	None	Studies evaluated <b>traditional Chinese exercises</b> (Tai Chi, Ba duan jin, qigong) for patients with T2D, mean age range 49-70 years.  Tai Chi was associated with greater improvements in the physical function domain (MD = 5.92 [95% CI 0.68 to 11.16], 5 RCTs), but not on the mental health domain of the SF-36 form. There was no effect of ba duan jin on QOL as reported by 2 studies.	LOW <sup>d</sup>	
Zhou 2019 (36) Moderate	5 RCTs N=NR	No serious risk of bias	Serious inconsistency	No serious indirectness	Serious imprecision	None	Studies evaluated <b>Tai Chi</b> among adults with T2D, mean age range 36 to 70 years. Mean sessions of exercise ranged from 15 to 120 min with 2 to 14 sessions per week. Total intervention duration ranged from 4 to 24 weeks.  Tai Chi was associated with significant improvement in the physical function domain (MD = 7.07 [95% CI, -0.79 to 13.35], 5 RCTs), bodily pain domain (MD = 4.30 [95% CI, 0.83 to 7.77], 5 RCTs), and social function domain (MD = 13.84 [95% CI, 6.22 to 21.47], 5 RCTs) of the SF-36, but not the other 5 components of QOL.	LOW <sup>e</sup>	

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		Risk of bias	Inconsistency	Indirectness	Imprecision	Other			
Review credibility	No. of participants								
<b>Disease progression<sup>a</sup></b>									
Jang 2019 (13) Low	23 RCTs or CCTs N=723	Serious risk of bias	Serious inconsistency	Serious indirectness	No serious imprecision	See next column	<p>Studies compared <b>any exercise intervention</b> with no intervention among adults with diabetes in Korea, mean age 60 years.</p> <p>Compared with non-exercise control groups, exercise interventions were associated with a statistically significant difference in <b>HbA1c</b> (MD = -0.58% [95% CI, -0.80 to -0.27], 17 studies, n=425) at post-test.</p> <p>Greater reductions in HbA1c seen among those with higher HbA1c values at baseline. Studies of aerobic exercise or combined aerobic exercise and resistance training showed bigger effects on HbA1c than those testing resistance training only. No differences in effects according to exercise duration</p>	VERY LOW <sup>f</sup>	<p><a href="#">34 ESRs</a></p> <p>Insufficient evidence was available to determine the relationship between physical activity and indicators of progression of neuropathy, nephropathy, retinopathy, and foot disorders. <b>PAGAC Grade: Not assignable.</b></p> <p>Strong evidence demonstrates an inverse association between aerobic activity, muscle-strengthening activity, and aerobic plus muscle-strengthening activity with risk of progression among adults with type 2 diabetes, as assessed by overall effects of physical activity on four indicators of risk of progression: glycated hemoglobin A1C, blood pressure, body mass index, and lipids. <b>PAGAC Grade: Strong.</b></p>
Liu, Ye, et al. 2019 (20) Moderate	24 RCTs N=962	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	Dose-response effect <sup>g</sup>	<p>Trials compared <b>resistance training</b> vs. control groups among persons with T2D (mean age range 45 to 71 years) with interventions ranging from 6 to 52 weeks.</p> <p>Resistance training was associated with greater reduction in <b>HbA1c</b> vs. control groups (MD = -0.45 [95% CI, -0.65 to -0.25], 20 trials, n=824). No differences were found in <b>fasting insulin</b> or <b>FBG</b> measures for all interventions; significant effects were found for high-intensity resistance training vs. control groups on fasting insulin (MD = -4.60 [95% CI, -7.53 to -1.67], 5 trials, n=174).</p>	HIGH <sup>h</sup>	
Song 2018 (29) Moderate	39 RCTs N=2,917	No serious risk of bias	Serious inconsistency	No serious indirectness	No serious imprecision	None	<p>Studies evaluated <b>traditional Chinese exercises</b> (Tai Ji Quan, Qigong, Ba Duan Jin) vs. no exercise intervention with T2D patients aged 41 to 80 years (mean age 59 years).</p> <p>Traditional Chinese exercises were associated with significantly greater reduction of percentage <b>HbA1c</b> (MD = -0.67% [95% CI -0.86% to -0.48%], 35 RCTS, n=2,940) and <b>FBG</b> (MD = -0.66 mmol/L [95% CI -0.95 to -0.37], 18 RCTS, n=1,433).</p>	MODERATE <sup>i</sup>	<p>Insufficient evidence was available to determine the relationship between tai chi, qigong, and yoga exercise on four indicators of risk of progression: hemoglobin A1C, blood pressure, body mass index, and lipids. <b>PAGAC Grade: Not assignable.</b></p>
Systematic review evidence	No. of studies/ Study design	Quality Assessment					Description of evidence Summary of findings	Certainty	US PAGAC evidence (39)
		Risk of bias	Inconsistency	Indirectness	Imprecision	Other			

Review credibility	No. of participants								
Chao 2018 (5) Moderate	14 RCTs N=798	Serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	Evidence of small studies effect	Trials evaluated the effects of <b>Tai Chi</b> on markers of diabetes compared with non-exercise or exercise control groups. Mean age ranged from 48-64 years. Interventions ranged from 3 to 7 days/week for 4 to 24 weeks total duration.  In pooled analysis, compared with non-exercise control groups, participants in the Tai Chi interventions had statistically significantly lower <b>FBG</b> (MD = -1.39 [95% CI, -1.95 to -0.84], 10 trials, n=489), <b>HbA1c</b> (MD = -0.73 [95% CI, -0.95 to -0.52], 7 trials, n=293), and <b>2hPBG</b> (MD = -2.07 [95% CI -2.89 to -1.26], 5 trials, n=82).	LOW <sup>i</sup>	
Lauche 2017 (15) Moderate	7 RCTs N = 361	Serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None	Studies evaluated the effects of <b>Tai Chi or qigong</b> for the treatment of diabetes compared with no intervention, conventional exercise, sham exercise, or resistance training. Intervention duration ranged from 6 weeks to 6 months (median 12 weeks), with median sessions of 2 days/week.  Pooled results showed statistically significant benefits of Tai Chi/qigong vs. no exercise control for <b>FBG</b> (MD = -8.88 mg/dL [95% CI, -16.73 to -1.03], 2 trials, n=85) and <b>HOMA</b> (MD = -2.86% [95% CI, 5.35 to -0.38], 2 trials, n=60). There was no effect on measures of <b>HbA1c</b> (MD = -0.46% [95% CI, -0.96 to 0.03], 4 trials, n=161). No differences were found when comparing Tai Chi/qigong with other forms of exercise.	MODERATE <sup>k</sup>	
Systematic review evidence Review credibility	No. of studies/ Study design No. of participants	Quality Assessment					Description of evidence Summary of findings	Certainty	US PAGAC evidence (39)
		Risk of bias	Inconsistency	Indirectness	Imprecision	Other			
Xia 2019 (33) Low	17 RCTs N=NR	Serious risk of bias	Serious inconsistency	No serious indirectness	No serious imprecision	None	Studies evaluated the effects of <b>Tai Chi</b> vs. active or non-active control among individuals with T2D. Number of Tai Chi sessions ranged from 36 to 336, with most having 2 to 7 sessions weekly with 30-60 min per session.  Tai Chi was associated with a significant effect on <b>FBG</b> (SMD = -0.54 [95% CI, -0.91 to -0.16], 13 RCTS, n=616) and <b>HbA1c</b> (SMD = -0.68 [95% CI, -1.17 to 0.19], 9 RCTS, n=517).	LOW <sup>i</sup>	
Yu 2018 (34) Moderate	22 RCTs 2 CCTs N=NR	Serious risk of bias	Serious inconsistency	No serious indirectness	Serious imprecision	None	Studies evaluated <b>traditional Chinese exercises</b> (Tai Chi, Ba duan jin, qigong) for patients with T2D, mean age range 49-70 years.  Tai Chi practice for at least 150 min/week was associated with lowered <b>HbA1c</b> (MD = -1.48 [95%	VERY LOW <sup>m</sup>	

							CI, -2.58% to -0.39%, 6 RCTs) and <b>FBG</b> (MD = -1.14 mmol/L [95% CI, -1.78 to -0.50], 6 RCTs). Ba duan jin was significantly associated with <b>HbA1c</b> (MD = -0.77 [95% CI -0.97 to -0.56], 12 RCTs) and <b>FBG</b> (MD = MD = -0.82 mmol/L [95% CI, -1.005 to -0.59], 12 RCTs).		
Zhou 2019 (36) Moderate	23 RCTs N=1,234	No serious risk of bias	Serious inconsistency	No serious indirectness	No serious imprecision	None	<p>Studies evaluated <b>Tai Chi</b> among adults with T2D, mean age range 36 to 70 years. Mean sessions of exercise ranged from 15 to 120 min with 2 to 14 sessions per week. Total intervention duration ranged from 4 to 24 weeks.</p> <p>Tai Chi was associated with significant improvement in <b>HbA1c</b> (MD=-0.88% [95% CI, -1.45 to -0.31], 14 RCTs) and <b>FBG</b> (SMD = -0.67 [95% CI, -0.87 to -0.47], 21 RCTs)</p>	MODERATE <sup>n</sup>	

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Thind 2017 (31) Low	23 RCTs N=2,473	Serious risk of bias	Serious inconsistency	No serious indirectness	Serious imprecision	None	<p>Studies evaluated the effects of <b>yoga</b> on adults with T2D (mean age, 53 years). Median number of yoga sessions was 50 with median duration of each session of 60 minutes. Intervention duration ranged from &lt;1 week to 6 months.</p> <p>Yoga was associated with significant differences in <b>HbA1c</b> (ES = 0.36 [95% CI, 0.16 to 0.56], 16 RCTs) and <b>FBG</b> (ES = 0.58 [95% CI, 0.40 to 0.76], 20 RCTs) at 8 weeks or longer follow-up.</p>	LOW <sup>m</sup>	
De Nardi (8)2018 Moderate	7 RCTs N=184	Serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None	<p>Trials comparing effects of <b>HIIT vs. MICT</b> in individuals with prediabetes (2 trials, n=64, mean age 52 years) and T2D (5 trials, n=120, mean age 61 years). Duration of interventions ranged from 12 to 16 weeks for trials among persons with T2D and 2 to 4 weeks for trials among persons with prediabetes.</p> <p>No differences were found between HIIT and MICT on measures of <b>FBG</b> (MD = 0.11 [95% CI, -0.45 to 0.67], 4 trials, n=82) or <b>HbA1c</b> (MD = -0.17 [95% CI -0.36 to 0.02], 5 trials, n=119) among patients with T2D. One study among patients with prediabetes found greater reduction in <b>FBG</b> among those in the MICT vs. HIIT groups.</p>	MODERATE <sup>k</sup>	
Liu, Zhu, et al. 2019 (19) Moderate	13 RCTs N=345	No serious risk of bias	Serious inconsistency	No serious indirectness	Serious imprecision	None	<p>Trials comparing effects of <b>HIIT vs. MICT or no intervention</b> in individuals with T2D. HIIT interventions ranged from 11 to 16 weeks with a median of 3 sessions/week with total training per session ranging from 30 seconds to 4 minutes.</p> <p>Statistically significant greater difference in changes in <b>HbA1c</b> among those in HIIT vs. MICT intervention groups (MD = -0.37 [95% CI, -0.55 to -0.19], 10 trials, n=220). No difference was found between HIIT and no exercise control groups on HbA1c (MD = -0.39 [-0.81 to 0.02], 3 trials, n=63). No differences were found between HIIT vs. MICT or HIIT vs. non-exercise control groups on measures of <b>FBG</b>, <b>fasting insulin</b>, or <b>HOMA</b>.</p>	LOW <sup>o</sup>	
Systematic review evidence Review credibility	No. of studies/ Study design No. of participants	Quality Assessment					Description of evidence Summary of findings	Certainty	US PAGAC evidence (39)
		Risk of bias	Inconsistency	Indirectness	Imprecision	Other			

Qui 2017 (25) Moderate	7 RCTs N=189	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None	Patients with type 2 diabetes, mean age 59 years, mean BMI 30.4 kg/m <sup>2</sup> . Studies evaluated <b>HIIT vs. MICT or no-exercise control groups</b> . Frequency of HIIT ranged from 2 to 5 times per week, with total length (maximal exercise plus recovery interval) ranged from 20 to 60 minutes with most intervals lasting 1 to 4 minutes. Intervention duration ranged from 12 to 16 weeks.  INT was associated with statistically significantly decreased <b>HbA1c</b> by 0.26% (95% CI, -0.46 to -0.07%, 5 RCTs) compared with MICT and by 0.83% (95% CI, -1.39% to -0.27%, 4 RCTs) compared with no-exercise control groups.	HIGH <sup>h</sup>
Rees 2017 (27) Moderate	5 RCTs 4 pre-post N=222	No serious risk of bias	No serious inconsistency	No serious indirectness	Serious imprecision	None	Studies evaluated effect of <b>aquatic exercise vs. land-based exercises or no-exercise control groups</b> . Most interventions lasted 8-12 weeks.  No significant difference was found between land exercise and aquatic exercise on <b>HbA1c</b> (MD = -0.02% [95% CI, -0.71 to 0.66], 3 trials, n=83) or <b>FBG</b> (MD = -5.06 mg/dL [95% I, -12.32 to 2.21], 5 studies). There was a significant difference between aquatic exercise and no-exercise in <b>HbA1c</b> (MD = -0.96% [95% CI -1.87 to -0.05], 2 trials, n=60).	MODERATE <sup>p</sup>

Abbreviations: 1RM = 1 repetition maximum; 2hPBG = two-hour postprandial blood glucose; BMI = body mass index; CCT = controlled clinical trial; CI = confidence interval; ES = effect size (Hedge's g); FBG = fasting blood glucose; HbA1c = hemoglobin A1c; HIIT = high-intensity interval training; HOMA = Homeostatic model assessment; INT = aerobic interval training; kg/m = kilograms per meter; MD = mean difference; mg/dL = milligrams per deciliter; MICT = moderate-intensity continuous training; NA = not applicable; SF-36 = short-form QOL questionnaire; SMD = standardized mean difference; T2D = type 2 diabetes

<sup>†</sup> Serious indirectness indicates measurement of intermediate/indirect outcomes or heterogeneity in exposures and comparisons assessed; certainty of evidence was not always downgraded for indirectness if it was not judged to impact the certainty in the findings for the outcome evaluated in the review

<sup>a</sup> Included measures of glycemic control; did not include measures of other cardiometabolic risk factors (i.e., blood pressures, lipids, adiposity)

<sup>b</sup> Certainty of evidence downgraded given serious indirectness in measures of effect and imprecision in effect estimates

<sup>c</sup> Certainty of evidence upgraded given no major limitations

<sup>d</sup> Certainty of evidence downgraded given serious risk of bias and imprecision in effect estimates (wide confidence intervals ranged from clinically significant to non-clinically significant)

<sup>e</sup> Certainty of evidence downgraded given serious inconsistency and imprecision (very wide confidence intervals)

<sup>f</sup> Certainty of evidence downgraded given serious risk of bias, serious inconsistency (heterogeneity) of effects, and serious indirectness (comparison of measures of HbA1c at post-test only)

<sup>g</sup> High-intensity interventions (intensity between 75% and 100% 1RM) were associated with greater differences in HbA1c vs. low-to-moderate intensity interventions (intensity between 20% and 75% 1RM)

<sup>h</sup> Certainty of evidence not downgraded

<sup>l</sup> Certainty of evidence downgraded given substantial heterogeneity in pooled analysis ( $I^2 > 80\%$ )

<sup>j</sup> Certainty of evidence downgraded given serious risk of bias and possible publication bias

<sup>k</sup> Certainty of evidence downgraded given serious risk of bias for most included trials

<sup>l</sup> Certainty of evidence downgraded given serious risk of bias and inconsistency ( $I^2 > 70\%$ )

<sup>m</sup> Certainty of evidence downgraded due to inconsistency and imprecision in effect estimates; not downgraded for risk of bias because the review did not assess this

<sup>n</sup> Certainty of evidence downgraded given serious inconsistency (heterogeneity) of effects

<sup>o</sup> As assigned by review authors. Certainty of evidence downgraded due to inconsistency and imprecision

<sup>p</sup> Certainty of evidence downgraded given serious imprecision (wide confidence interval in effect estimates)