Coffee Consumption and Insulin Resistance and Sensitivity

Subjects: Agriculture, Dairy & Animal Science Contributor: Myeong Gyu Kim

Long-term coffee consumption has a nonsignificant effect on insulin resistance and sensitivity.

Keywords: coffee ; insulin resistance ; insulin sensitivity

1. Introduction

Coffee has become one of the most famous drinks today and is increasingly consumed globally. Coffee contains various bioactive ingredients that can positively or negatively affect the human body ^{[1][2]}. Coffee consumption is inversely associated with total mortality ^{[3][4][5]}, endometrial cancer ^[6], colon cancer ^[7], hepatic cancer ^[8], prostate cancer ^[9], and chronic liver disease ^[10].

Diabetes mellitus is a rapidly growing global problem with large social, health, and economic consequences ^[11]. Many cohort and nested case-control studies have been conducted on the association between coffee consumption and type 2 diabetes. A meta-analysis of 30 epidemiologic studies found that drinking a cup of coffee daily reduces the risk of diabetes by 6% (relative risk (RR) = 0.94; 95% confidence interval (CI), 0.93–0.95) ^[12]. The effect size between caffeinated coffee and decaffeinated coffee consumption did not differ significantly (RR = 0.93; 95% CI = 0.90–0.96 vs. RR = 0.94; 95% CI = 0.90–0.98) ^[12]. The association between coffee consumption and diabetes has been shown only in epidemiologic studies; randomized clinical trials (RCTs) directly verifying this association are limited. Instead, RCTs have studied the effects of coffee consumption on glucose and insulin levels. In a recent meta-analysis, coffee and decaffeinated coffee consumption did not significantly affect fasting blood glucose concentration (mean difference (MD) = 1.34 mg/dL; 95% CI = –0.52–3.20 mg/dL and MD = 5.28 mg/dL; 95% CI = –5.34–15.91 mg/dL, respectively) ^[13]. Moreover, the effects of coffee and decaffeinated coffee at 2-h post-75-g glucose load plasma glucose concentration were not significant (MD = –23.99 mg/dL; 95% CI = –63.78–15.81 mg/dL and MD = 12.27 mg/dL; 95% CI = –8.52–33.07 mg/dL) ^[13]. Coffee significantly altered fasting insulin concentration (MD = 1.1 μ IU/mL; 95% CI = 0.17–2.03 μ IU/mL) ^[13]. However, measurements of these concentrations have limitations in evaluating insulin sensitivity and resistance.

The hyperinsulinemic-euglycemic clamp is the gold standard for assessing insulin sensitivity in humans ^[14]. However, this method is not suitable for use in clinical practice because it is a time-consuming, labor-intensive, and expensive method, and requires skilled examiners. Several surrogate indices (e.g., homeostasis model assessment (HOMA), quantitative insulin sensitivity check index (QUICKI), Matsuda, McAuley, Belfiore, Cederholm, Avignon, and Stumvoll indexes) have been developed as alternative measures of insulin resistance or sensitivity ^{[15][16]}.

Few studies have assessed the effects of coffee consumption on insulin sensitivity/resistance indices. Until 2017, only two studies were included in meta-analysis and systematic reviews ^{[13][17]}. Newer studies have been conducted since then, which makes it essential to evaluate the influence of coffee consumption on insulin resistance or sensitivity through a meta-analysis.

2. Coffee Consumption and Insulin Resistance and Sensitivity

Herein evaluated the effects of coffee consumption on HOMA-IR and Matsuda index by analyzing four RCTs. HOMA-IR is used in many studies as a tool for evaluating insulin resistance and mainly reflects liver insulin resistance ^{[18][19]}. This index was more reliable to assess insulin resistance than the fasting glucose/insulin ratio and was an independent predictor of cardiovascular disease ^{[20][21]}. Matsuda index is a simple index of whole-body insulin sensitivity including liver and muscle ^{[19][22]}. Other surrogate indices, except for HOMA-IR and Matsuda, were rarely used in coffee studies. Although not included in the search terms, insulin resistance indices using C-peptide levels (e.g., clamp-like index (CLIX),

C-peptide immunoreactivity insulin resistance (CPR-IR)) exist ^{[23][24]}. However, these indices have not been used previously to assess the effects of coffee.

A previous meta-analysis reported no significant effect of coffee consumption on HOMA-IR relative to the control by analyzing two RCTs ^[13]. Herein showed that coffee consumption significantly decreased HOMA-IR. However, the robustness of the result was not warranted. The significance of our result was driven by one significant result from a large-weighted study. The weight of the crossover design is generally larger than that of parallel design in a meta-analysis ^[25]. The characteristics of the group showing significant results were different from those of other studies. They were young adults (aged 18–45 years), had a normal weight (BMI < 25 kg/m²), and did not have any metabolic syndrome including hypercholesterolemia. In such a population, the possibility of coffee consumption lowering insulin resistance cannot be ruled out. However, it is difficult to conclude that coffee consumption reduces insulin resistance from one study. Moreover, coffee consumption did not significantly affect the Matsuda index.

Although not included in this meta-analysis, in one non-RCT, HOMA-IR was 3.93, 4.10, and 4.22 in subgroups that consumed zero, four, and eight cups of coffee daily, respectively ^[26]. The difference was not significant, and other markers of glucose metabolism also were not significantly different ^[26]. Some studies reported HOMA for β -cell function (HOMA-B) as an indicator of insulin resistance. There was no significant difference in HOMA-B between the coffee consumption and placebo groups in a study by Alperet et al. ^[27]. Mansour et al. conducted an RCT that administered two main coffee components, caffeine and chlorogenic acid, to patients with non-alcoholic fatty liver disease and type 2 diabetes ^[28]. HOMA-IR between chlorogenic acid plus caffeine, chlorogenic acid, caffeine, and placebo did not differ significantly ^[28].

Previous studies showed that caffeine can lower insulin sensitivity and increase insulin resistance and glucose concentration ^{[29][30][31]}. MacKenzie et al. conducted a randomized crossover trial and found that 400 mg of caffeine (equivalent to two cups of coffee) per day decreases insulin sensitivity in young adults ^[31]. The mechanism of caffeine's effects on glucose metabolism has not been fully revealed, but several have been suggested. Caffeine inhibits glucose uptake and glycogen synthase activity in the skeletal muscle by competitively blocking adenosine receptors ^[32]. Other mechanisms include increased levels of epinephrine and free fatty acids that can increase insulin resistance after caffeine intake ^{[31][32]}. However, the nonsignificant effects of coffee on insulin resistance and sensitivity in the present meta-analysis might be due to other ingredients in coffee that may negate the effects of caffeine on insulin resistance and sensitivity ^[33]. Chlorogenic acid reduced glucose concentrations, and its metabolite, quinides, increased insulin sensitivity in rats ^[34]. Chlorogenic acid may competitively inhibit glucose absorption in the intestine and reduce hepatic glucose output through glucose-6-phosphatase inhibition ^[34].

3. Conclusions

Long-term caffeinated or decaffeinated coffee consumption does not negatively affect insulin resistance or sensitivity. There is no need to restrict coffee intake in non-diabetic, prediabetic, and diabetic individuals for fear of insulin resistance. In addition, more studies evaluating the effects of coffee consumption in healthy, young, and normal-weight individuals are needed.

References

- 1. Hu, G.L.; Wang, X.; Zhang, L.; Qiu, M.H. The sources and mechanisms of bioactive ingredients in coffee. Food Funct. 2019, 10, 3113–3126.
- Buldak, R.J.; Hejmo, T.; Osowski, M.; Buldak, L.; Kukla, M.; Polaniak, R.; Birkner, E. The Impact of Coffee and Its Selected Bioactive Compounds on the Development and Progression of Colorectal Cancer In Vivo and In Vitro. Molecules 2018, 23, 3309.
- 3. Je, Y.; Giovannucci, E. Coffee consumption and total mortality: A meta-analysis of twenty prospective cohort studies. Br. J. Nutr. 2014, 111, 1162–1173.
- 4. Crippa, A.; Discacciati, A.; Larsson, S.C.; Wolk, A.; Orsini, N. Coffee consumption and mortality from all causes, cardiovascular disease, and cancer: A dose-response meta-analysis. Am. J. Epidemiol. 2014, 180, 763–775.
- Freedman, N.D.; Park, Y.; Abnet, C.C.; Hollenbeck, A.R.; Sinha, R. Association of coffee drinking with total and causespecific mortality. N. Engl. J. Med. 2012, 366, 1891–1904.
- Je, Y.; Giovannucci, E. Coffee consumption and risk of endometrial cancer: Findings from a large up-to-date metaanalysis. Int. J. Cancer 2012, 131, 1700–1710.

- 7. Galeone, C.; Turati, F.; La Vecchia, C.; Tavani, A. Coffee consumption and risk of colorectal cancer: A meta-analysis of case-control studies. Cancer Causes Control 2010, 21, 1949–1959.
- 8. Sang, L.X.; Chang, B.; Li, X.H.; Jiang, M. Consumption of coffee associated with reduced risk of liver cancer: A metaanalysis. BMC Gastroenterol. 2013, 13, 34.
- 9. Discacciati, A.; Orsini, N.; Wolk, A. Coffee consumption and risk of nonaggressive, aggressive and fatal prostate cancer--a dose-response meta-analysis. Ann. Oncol. 2014, 25, 584–591.
- 10. Torres, D.M.; Harrison, S.A. Is it time to write a prescription for coffee? Coffee and liver disease. Gastroenterology 2013, 144, 670–672.
- 11. Kaul, K.; Tarr, J.M.; Ahmad, S.I.; Kohner, E.M.; Chibber, R. Introduction to diabetes mellitus. Adv. Exp. Med. Biol. 2012, 771, 1–11.
- 12. Carlstrom, M.; Larsson, S.C. Coffee consumption and reduced risk of developing type 2 diabetes: A systematic review with meta-analysis. Nutr. Rev. 2018, 76, 395–417.
- 13. Kondo, Y.; Goto, A.; Noma, H.; Iso, H.; Hayashi, K.; Noda, M. Effects of Coffee and Tea Consumption on Glucose Metabolism: A Systematic Review and Network Meta-Analysis. Nutrients 2018, 11, 48.
- 14. Tam, C.S.; Xie, W.; Johnson, W.D.; Cefalu, W.T.; Redman, L.M.; Ravussin, E. Defining insulin resistance from hyperinsulinemic-euglycemic clamps. Diabetes Care 2012, 35, 1605–1610.
- 15. Gutch, M.; Kumar, S.; Razi, S.M.; Gupta, K.K.; Gupta, A. Assessment of insulin sensitivity/resistance. Indian J. Endocrinol. Metab. 2015, 19, 160–164.
- Pisprasert, V.; Ingram, K.H.; Lopez-Davila, M.F.; Munoz, A.J.; Garvey, W.T. Limitations in the use of indices using glucose and insulin levels to predict insulin sensitivity: Impact of race and gender and superiority of the indices derived from oral glucose tolerance test in African Americans. Diabetes Care 2013, 36, 845–853.
- 17. Reis, C.E.G.; Dorea, J.G.; da Costa, T.H.M. Effects of coffee consumption on glucose metabolism: A systematic review of clinical trials. J. Tradit. Complement. Med. 2019, 9, 184–191.
- 18. Wallace, T.M.; Levy, J.C.; Matthews, D.R. Use and abuse of HOMA modeling. Diabetes Care 2004, 27, 1487–1495.
- 19. Muniyappa, R.; Lee, S.; Chen, H.; Quon, M.J. Current approaches for assessing insulin sensitivity and resistance in vivo: Advantages, limitations, and appropriate usage. Am. J. Physiol. Endocrinol. Metab. 2008, 294, E15–E26.
- 20. Bonora, E.; Formentini, G.; Calcaterra, F.; Lombardi, S.; Marini, F.; Zenari, L.; Saggiani, F.; Poli, M.; Perbellini, S.; Raffaelli, A.; et al. HOMA-estimated insulin resistance is an independent predictor of cardiovascular disease in type 2 diabetic subjects: Prospective data from the Verona Diabetes Complications Study. Diabetes Care 2002, 25, 1135– 1141.
- 21. Keskin, M.; Kurtoglu, S.; Kendirci, M.; Atabek, M.E.; Yazici, C. Homeostasis model assessment is more reliable than the fasting glucose/insulin ratio and quantitative insulin sensitivity check index for assessing insulin resistance among obese children and adolescents. Pediatrics 2005, 115, e500–e503.
- 22. Matsuda, M.; DeFronzo, R.A. Insulin sensitivity indices obtained from oral glucose tolerance testing: Comparison with the euglycemic insulin clamp. Diabetes Care 1999, 22, 1462–1470.
- 23. Anderwald, C.; Anderwald-Stadler, M.; Promintzer, M.; Prager, G.; Mandl, M.; Nowotny, P.; Bischof, M.G.; Wolzt, M.; Ludvik, B.; Kästenbauer, T.; et al. The Clamp-Like Index: A novel and highly sensitive insulin sensitivity index to calculate hyperinsulinemic clamp glucose infusion rates from oral glucose tolerance tests in nondiabetic subjects. Diabetes Care 2007, 30, 2374–2380.
- Ohkura, T.; Shiochi, H.; Fujioka, Y.; Sumi, K.; Yamamoto, N.; Matsuzawa, K.; Izawa, S.; Kinoshita, H.; Ohkura, H.; Kato, M.; et al. 20/(fasting C-peptide × fasting plasma glucose) is a simple and effective index of insulin resistance in patients with type 2 diabetes mellitus: A preliminary report. Cardiovasc. Diabetol. 2013, 12, 21.
- 25. Curtin, F.; Altman, D.G.; Elbourne, D. Meta-analysis combining parallel and cross-over clinical trials. I: Continuous Outcomes. Stat. Med. 2002, 21, 2131–2144.
- 26. Kempf, K.; Herder, C.; Erlund, I.; Kolb, H.; Martin, S.; Carstensen, M.; Koenig, W.; Sundvall, J.; Bidel, S.; Kuha, S.; et al. Effects of coffee consumption on subclinical inflammation and other risk factors for type 2 diabetes: A clinical trial. Am. J. Clin. Nutr. 2010, 91, 950–957.
- Alperet, D.J.; Rebello, S.A.; Khoo, E.Y.; Tay, Z.; Seah, S.S.; Tai, B.C.; Tai, E.S.; Emady-Azar, S.; Chou, C.J.; Darimont, C.; et al. The effect of coffee consumption on insulin sensitivity and other biological risk factors for type 2 diabetes: A randomized placebo-controlled trial. Am. J. Clin. Nutr. 2020, 111, 448–458.
- 28. Mansour, A.; Mohajeri-Tehrani, M.R.; Samadi, M.; Qorbani, M.; Merat, S.; Adibi, H.; Poustchi, H.; Hekmatdoost, A. Effects of supplementation with main coffee components including caffeine and/or chlorogenic acid on hepatic,

metabolic, and inflammatory indices in patients with non-alcoholic fatty liver disease and type 2 diabetes: A randomized, double-blind, placebo-controlled, clinical trial. Nutr. J. 2021, 20, 35.

- 29. Lee, S.; Min, J.Y.; Min, K.B. Caffeine and Caffeine Metabolites in Relation to Insulin Resistance and Beta Cell Function in U.S. Adults. Nutrients 2020, 12, 1783.
- 30. van Dam, R.M.; Pasman, W.J.; Verhoef, P. Effects of coffee consumption on fasting blood glucose and insulin concentrations: Randomized controlled trials in healthy volunteers. Diabetes Care 2004, 27, 2990–2992.
- 31. MacKenzie, T.; Comi, R.; Sluss, P.; Keisari, R.; Manwar, S.; Kim, J.; Larson, R.; Baron, J.A. Metabolic and hormonal effects of caffeine: Randomized, double-blind, placebo-controlled crossover trial. Metabolism 2007, 56, 1694–1698.
- 32. Thong, F.S.; Derave, W.; Kiens, B.; Graham, T.E.; Ursø, B.; Wojtaszewski, J.F.; Hansen, B.F.; Richter, E.A. Caffeineinduced impairment of insulin action but not insulin signaling in human skeletal muscle is reduced by exercise. Diabetes 2002, 51, 583–590.
- 33. Arnlov, J.; Vessby, B.; Riserus, U. Coffee consumption and insulin sensitivity. JAMA 2004, 291, 1199–1201.
- 34. van Dam, R.M.; Hu, F.B. Coffee consumption and risk of type 2 diabetes: A systematic review. JAMA 2005, 294, 97– 104.

Retrieved from https://encyclopedia.pub/entry/history/show/39427