Impact of type 2 diabetes on aerobic capacity in postmenopausal women: an integrative review

Impacto do diabetes tipo 2 na capacidade aeróbica de mulheres pós-menopáusicas: uma revisão integrativa

Impacto de la diabetes tipo 2 en la capacidad aeróbica en mujeres posmenopáusicas: una revisión integradora

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REVISA

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RESUMO

Objetivo: compreender os fatores envolvidos na função cardiorrespiratória e na capacidade funcional em mulheres com DM2 na pós-menopausa durante o teste de esforço, por meio de dados obtidos na literatura recente. Métodos: Foram selecionados artigos publicados entre 2014 e 2024 nas bases PubMed, Web of Science e SCOPUS, utilizando os termos "menopause" AND "type 2 diabetes" AND "treadmill". Após aplicar os critérios de inclusão e exclusão, oito artigos foram identificados, mas apenas dois abordaram especificamente o tema proposto. Resultados: Um dos estudos mostrou que mulheres com DM2, na pré e pós-menopausa, apresentaram menor VO_2 máximo, cinética de VO_2 e pico de potência, além de uma maior adaptação do débito cardíaco em exercício submáximo, sugerindo que a queda no VO_2 não se deve ao DC. A menopausa não alterou os resultados, possivelmente pela idade (<60 anos) e alto IMC, que podem manter a produção de estrogênio. O outro estudo, com mulheres sem DM2, mas com ou sem histórico familiar da doença, não encontrou diferenças no metabolismo durante ou após o exercício. Conclusão: O DM2 reduz o consumo máximo de oxigênio em mulheres na pré e pós-menopausa. A menopausa isoladamente não mostrou efeito significativo, possivelmente devido à adiposidade, que pode ter atenuado seus impactos negativos.

Descritores: Menopausa. Diabetes Mellitus Tipo 2. Teste de Esforço Físico.

ABSTRACT

Objective: To understand the factors involved in cardiorespiratory function and functional capacity in postmenopausal women with DM2 during exercise testing, using data obtained from recent literature. Methods: Articles published between 2014 and 2024 were selected from PubMed, Web of Science, and SCOPUS databases using the terms "menopause" AND "type 2 diabetes" AND "treadmill." After applying the inclusion and exclusion criteria, eight articles were identified, but only two specifically addressed the proposed topic. Results: One of the studies showed that women with DM2, both pre- and post-menopausal, had lower VO_2 max, VO_2 kinetics, and peak power, as well as greater adaptation of cardiac output during submaximal exercise, suggesting that the decrease in VO_2 is not due to CD. Menopause did not alter the results, possibly due to age (<60 years) and high BMI, which may maintain estrogen production. The other study, with women without DM2 but with or without a family history of the disease, found no differences in metabolism during or after exercise. Conclusion: T2D reduces maximum oxygen consumption in pre- and postmenopausal women. Menopause alone did not show a significant effect, possibly due to adiposity, which may have mitigated its negative impacts
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Descriptors: Menopause. Type 2 Diabetes Mellitus. Exercise Test.

RESUMEN

Objetivo: Comprender los factores que intervienen en la función cardiorrespiratoria y la capacidad funcional en mujeres con DM2 posmenopáusicas durante la prueba de esfuerzo, a partir de datos obtenidos en la literatura reciente.. Métodos: Se seleccionaron artículos publicados entre 2014 y 2024 en las bases de datos PubMed, Web of Science y SCOPUS, utilizando los términos «menopause» AND «type 2 diabetes» AND «treadmill». Tras aplicar los criterios de inclusión y exclusión, se identificaron ocho artículos, pero solo dos abordaban específicamente el tema propuesto. Resultados: Un estudio demostró que las mujeres premenopáusicas y posmenopáusicas con diabetes mellitus tipo 2 (DM2) presentaban un VO_2 máx., una cinética del VO_2 y una potencia pico más bajos, así como una mayor adaptación del gasto cardíaco durante el ejercicio submáximo. Esto sugiere que la disminución del VO_2 no se debía al CO. La menopausia no alteró los resultados, posiblemente debido a la edad (<60 años) y al IMC elevado, que podrían mantener la producción de estrógenos. El otro estudio, realizado en mujeres sin DM2, pero con o sin antecedentes familiares de la enfermedad, no encontró diferencias en el metabolismo durante ni después del ejercicio.Conclusión: DM2 reduce el consumo máximo de oxígeno en mujeres pre y posmenopáusicas. La menopausia por sí sola no mostró un efecto significativo, posiblemente debido a la adiposidad, que puede haber atenuado sus impactos negativos.

Descriptores: Menopausia. Diabetes mellitus tipo 2. Prueba de esfuerzo.

Introduction

Menopause is a biological process characterized by a significant reduction in estrogen production, which modulates various physiological functions in the female body.[1] Estrogen plays a cardiovascular and metabolic protective role, regulating fat distribution, insulin sensitivity, and vascular function. Its decline during menopause increases visceral adiposity, vascular resistance, and worsens the lipid profile, increasing the risk of T2DM, in addition to favoring autonomic imbalance, increasing cardiovascular risk.[2-4]

Furthermore, the association between estrogen deficiency and T2DM can result in decreased cardiorespiratory function.[5,6] Several factors may be associated, such as cardiovascular and metabolic changes, contributing to a reduction in the anaerobic threshold.[4,5]

Objective

The present review aimed to search the recent literature for data on the cardiorespiratory function of postmenopausal women with T2DM during exercise testing, in order to better understand the factors involved in cardiorespiratory function and functional capacity in this population.

Method

The search for articles was conducted in the PubMed, Web of Science, and SCOPUS databases, using combinations of the descriptors "menopause," "type 2 diabetes," and different descriptors related to exercise testing ("exercise treadmill," "exercise stress," and "exercise test"). Articles published in the last 10 years, which evaluated cardiorespiratory function in postmenopausal women with T2DM, were included. Literature reviews and case reports were excluded. 32 articles were identified. The screening was carried out independently by four researchers, who discussed and reached final agreement.

Results

After applying the eligibility criteria, 24 articles were excluded. After careful evaluation of the eight remaining articles, six were discarded for not contemplating the objectives of the study. Thus, only two articles were used in the review.

Kiely et al.[7] researched the influence of menopause on the T2DM-induced impairment of cardiorespiratory performance, focusing on VO_2 peak and VO_2 kinetics during an exercise test on a cycle ergometer with analysis of VO_2 and submaximal cardiac output. 22 women with T2DM and 22 non-diabetic women matched for menopausal status and age were evaluated. All were under 60 years old.

Lagacé et al.[8] investigated the impact of a family history of T2DM in postmenopausal women without T2DM during submaximal aerobic exercise (cycle

ergometer). The study included 19 inactive women, aged 60−75, without chronic diseases, postmenopausal, stratified by family history (1st-degree relative) of T2DM. Gas exchange, heart rate, and plasma biochemical markers were monitored. Table I below summarizes the main results of the included articles.

Table I – Characteristics of the included studies

Study	Main finding	Limitations
Kiely et al. (2015)	T2DM reduced VO_2 peak and slowed VO_2 kinetics (phase II), independent of menopause. In healthy controls, the relative difference in the time constant between pre- and post-menopause was ~12% (vs ~3% in T2DM groups). In submaximal exercise, absolute CO was lower in T2DM, but proportional adaptation was greater → heart is not the main limiter.	Small sample size; menopausal status assessment by self-report; absence of age of menopause onset.
Lagacé et al. (2022)	There were no differences between groups in substrate oxidation/concentrations; however, the group with a family history performed the test at a lower % of HR reserve and completed more tests.	Small sample size; use of indirect methods to estimate fat oxidation; absence of hormonal measurements.

Source: Prepared by the authors (2025). T2DM=Type 2 Diabetes Mellitus; VO_2 =Oxygen uptake; CO=Cardiac Output.

Discussion

The transition to menopause increases the incidence of CVD and T2DM.[7] The protective effect of estrogen seems to be influenced by the presence of T2DM, given that diabetic women have a cardiovascular risk equivalent to that of diabetic men.[7] The presence of T2DM, with or without cardiovascular complications, is frequently associated with reduced maximum oxygen uptake.[5,6,9–11] Therefore, T2DM associated with estrogen deficiency can impact the health and physical performance of these women.

Mercuro et al.[2], report that menopause is related to a reduction in physical exercise tolerance. Regensteiner et al.[5] compared cardiorespiratory responses to exercise between premenopausal and postmenopausal women trained in endurance and found that postmenopausal women exhibited lower VO_2 compared to eumenorrheic women at the ventilatory threshold.

Kiely et al.[7] proposed that T2DM would have a more accentuated impact on the reduction of VO_2 peak in premenopausal women than in postmenopausal women. However, the results showed that women with T2DM presented reductions in absolute VO_2 peak compared to non-diabetic women, regardless of menopause. A deceleration in VO_2 kinetics was observed, suggesting that T2DM directly impacts cardiorespiratory function, independent of hormonal changes associated with menopause.

In this study, serum hormone concentration was not evaluated, in addition to not considering the age of menopause onset. Evidence suggests that both the age of menopause onset and the duration of the climacteric can affect cardiovascular parameters, which may have contributed to the observed results.

The change in VO_2 kinetics observed by Kiely et al. 7 indicates that the capacity to adjust to oxygen demand during submaximal exercise is compromised due to T2DM. Clinically, it can reduce exercise tolerance,[14] corroborating previous studies. [5,11–13]

Kiely et al.[7] also observed that, although there was a reduction in absolute cardiac output (CO) values in the T2DM groups during submaximal exercise, after adjustment for load and effort, a proportionally greater cardiovascular adaptation was actually observed in these individuals. The findings are consistent with Regensteiner et al.[8] who state that there is no change in resting cardiac function in premenopausal women with T2DM. Therefore, the cardiac response does not seem to be the determining factor for VO_2 kinetics in individuals with uncomplicated T2DM. Hormonal changes that occur during the menopausal period may contribute to the development of metabolic and vascular complications, indirectly associated with VO_2 kinetics. [8]

Furthermore, menopause can impact weight, body composition, and fat distribution, increasing the risk of developing T2DM.[8] A positive family history of T2DM represents a significant risk factor, elevating the probability of developing pre-diabetes by up to 40%.[15] Allerton et al.[16] investigated metabolic flexibility in individuals with a positive maternal history of T2DM compared to those without a family history of the disease. The authors observed that individuals with a family history of T2DM presented compromised fat metabolism during high-intensity interval exercise. However, Lagacé et al.[8] showed no differences in metabolism or substrate oxidation during submaximal exercise between similar groups. Differences between the studies may have occurred due to methodology, given that Allerton et al.[16] evaluated a postprandial context, while Lagacé et al.[10] focused only on exercise metabolism. Lagacé et al.[8] suggest that metabolic defects associated with a family history are limited to contexts where insulin action is critical, such as during higher intensity exercise or metabolic stress situations.

Lagacé et al.[8] postulated that postmenopausal women could be exempt from metabolic changes observed in younger insulin-resistant populations and that the increased risk of developing T2DM associated with the menopausal transition masks the differences imposed by the family history of T2DM. The hypotheses of Lagacé et al.[8] highlight the complexity of the interactions between hormonal factors, metabolic factors, and the family history of T2DM, which influence lipid metabolism in different age groups and physiological conditions.

An interesting observation was that all participants with a family history of T2DM completed the exercise test, while half of the control group (without a family history) did not complete it, despite both groups having similar maximum aerobic capacities.[8] The authors suggested that individuals with a family history of T2DM may have some physiological adaptations that allow for better exercise tolerance, despite the increased risk of developing T2DM.[8, 17]

The findings of this review indicate that women with T2DM show a significant reduction in maximum VO_2, suggesting lower efficiency in oxygen consumption and compromised aerobic capacity. This limitation seems to be associated

with lower peripheral oxygen extraction, possibly related to endothelial dysfunction and reduced muscle capillarization. Despite this, a compensatory increase in cardiac output was observed, suggesting a hemodynamic adjustment to attenuate the effects of lower tissue oxygenation.[7] The lower mechanical efficiency in women with T2DM may be related to musculoskeletal and metabolic changes, such as greater dependence on anaerobic metabolism and the presence of insulin resistance.[5,17] The importance of targeted strategies to optimize cardiorespiratory fitness is emphasized, aiming to improve functional capacity and reduce cardiovascular risk in this population.[9]

The review presents the reduced number of included articles as the main limitation, which limits the generalization of the results. This is due to the scarcity of studies specifically addressing the cardiorespiratory function of postmenopausal women with T2DM.

Conclusion

In conclusion, women with T2DM have impaired exercise performance, but family history does not appear to be associated with such effects in healthy postmenopausal women. The findings suggest that maintaining metabolic health and early exercise practice can prevent future complications. Furthermore, although menopause has not shown a direct effect on the results, its influence on cardiorespiratory function cannot be ruled out, given that the role of endogenous estrogen, especially in women with greater adiposity, may have contributed to mitigating the negative effects of menopause. The reduced number of publications addressing the subject highlights the need for studies to investigate and prevent the consequences of menopause and T2DM on cardiorespiratory function and women's health.

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