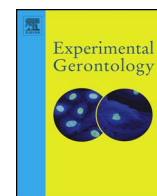




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High-intensity body weight training is comparable to combined training in changes in muscle mass, physical performance, inflammatory markers and metabolic health in postmenopausal women at high risk for type 2 diabetes mellitus: A randomized controlled clinical trial

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ABSTRACT

Objective: This study compared the effects of 12 weeks of high-intensity interval body weight training (HIBWT) with combined training (COMT; aerobic and resistance exercises on body composition, a 6-minute walk test (6MWT; physical performance), insulin resistance (IR) and inflammatory markers in postmenopausal women (PW) at high risk of type 2 diabetes mellitus (TDM2).

Methods: In this randomized controlled clinical study, 16 PW at high risk of TDM2 were randomly allocated into two groups: HIBWT ($n = 8$) and COMT ($n = 8$). The HIBWT group performed a training protocol (length time ~28 min) consisting of ten sets of 60 s of high intensity exercise interspersed by a recovery period of 60 s of low intensity exercise. The COMT group performed a training protocol (length time ~60 min) consisting of a 30 min walk of moderate intensity following by five resistance exercises. All training sessions were performed in the university gym facility three days a week (no consecutive days) for 12 weeks. All outcomes (body composition, muscle function, and IR and inflammatory markers) were assessed at the baseline and at the end of the study. **Results:** Both groups increased ($P < 0.05$) muscle mass index (MMI), 6MWT, and interleukin 1 receptor antagonist and decreased fasting glucose, glycated hemoglobin, Insulin, HOMA-IR, and monocyte chemoattractant protein-1 (trend, $P = 0.056$). HIBWT effects were indistinguishable ($P > 0.05$) from the effects of COMT. There was a significant ($P < 0.05$) interaction of time by the group in muscle strength, indicating that only the COMT increased the muscle strength.

Conclusions: This study suggests that changes in HOMA, IL-1ra, 6MWT, and MMI with HITBW are similar when compared to COMT in PW at high risk of TDM2.

Trial registration: The patients were part of a 12-week training study ([ClinicalTrials.gov](https://clinicaltrials.gov) Identifier: NCT03200639).

1. Introduction

Postmenopausal period is accompanied by changes in body composition, which are characterized by an increase in body fat (obesity

and reduction in muscle mass, concomitantly with a reduction in physical performance (Kamel et al., 2002; Toth et al., 2000). In addition, such changes in body composition are related to chronically increased levels of inflammatory markers (such as C-reactive protein; CRP,

Abbreviations: 6MWT, six-minute walk test; COMT, combined training; HIBWT, high-intensity body weight training; IR, insulin resistance; MMI, muscle mass index; PW, postmenopausal women; TDM2, type 2 diabetes mellitus

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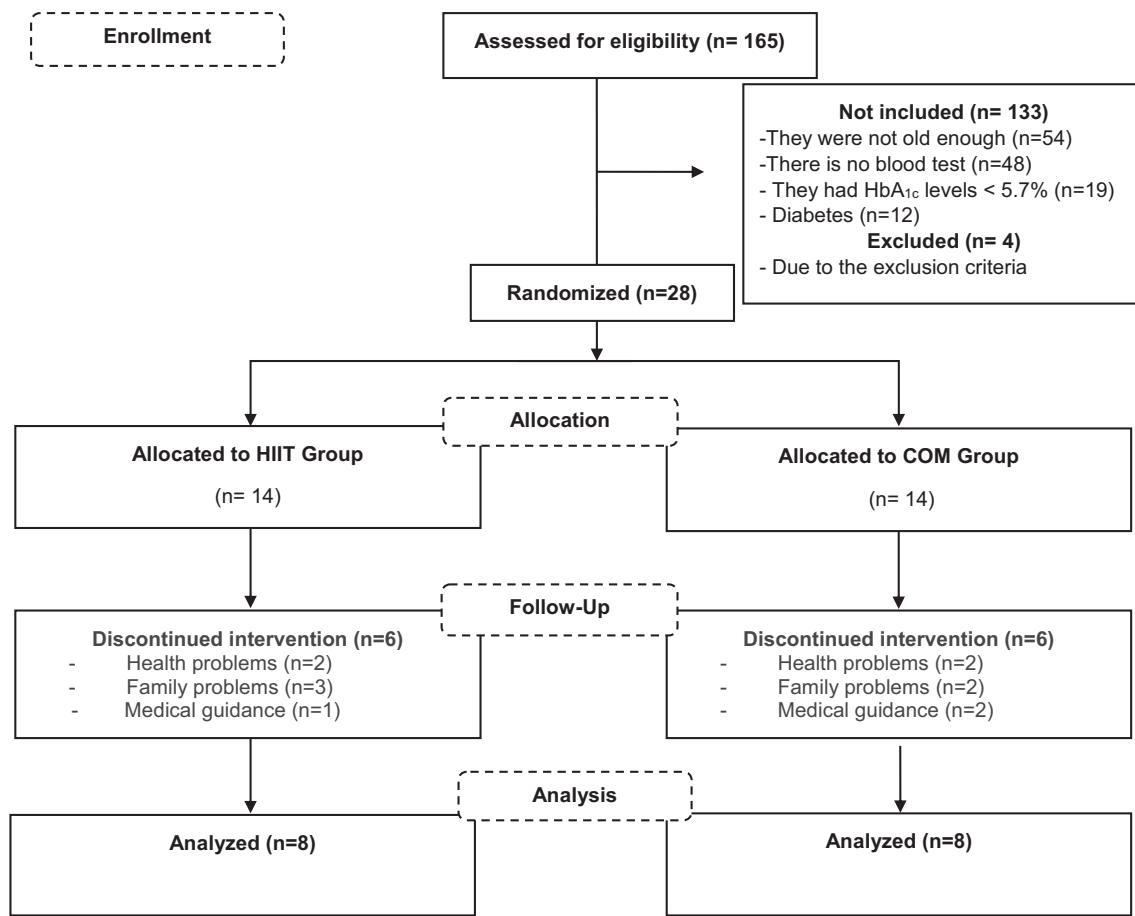


Fig. 1. Consort flow diagram showing numbers of patients at each stage of the trial.

monocyte chemoattractant protein-1; MCP-1, interleukin-6; IL-6 and interleukin-1 receptor antagonist; IL-1ra) (Visser et al., 2002; Piche et al., 2005; Franceschi & Campisi, 2014) termed low-grade inflammation (Franceschi & Campisi, 2014). These inflammatory markers are associated with insulin resistance (IR) and precede the onset of type 2 diabetes mellitus (TDM2) (Grossmann et al., 2015; Herder et al., 2006). Moreover, the reduction in physical performance and muscle mass elicits a synergic effect on obesity-related IR (Cleasby et al., 2016).

Conversely, previous evidence has shown that a reduced physical activity (Duval et al., 2013), rather than increased food intake (Duval et al., 2013), is the underlying mechanism of menopause-associated changes in body composition. Regular physical activity is an important non-pharmacological strategy for preventing body composition changes and TDM2 in older and middle-aged adults (Colberg et al., 2010; Garber et al., 2011). Public health guidelines recommend that healthy older adults participate in 150 min of moderate-intensity physical activity per week, combining resistance exercise with aerobic exercise (combined training; COMT) (Colberg et al., 2010; Garber et al., 2011). It has been shown that COMT improves body fat, muscle mass, IR and low-grade inflammation in older and middle-aged adults (Colberg et al., 2010; Garber et al., 2011). However, lack of time is commonly cited as a barrier for people to meet the guideline recommendations (Reichert et al., 2007; Korkiakangas et al., 2009a). In this context, high intensity interval training (HIIT), which involves repeated brief bouts of fast and intense exercise followed by periods of recovery, has been highlighted. It has been shown that HIIT provides greater reduction in body fat and IR than moderate-intensity continuous training (Maillard et al., 2016; Irving et al., 2008; Cassidy et al., 2017; Jelleyman et al., 2015). Thus, as HIIT requires less time spent on exercising, HIIT has been considered an alternative time-efficient treatment strategy to improve glycemic

control in patients at high risk of TDM2. (Cassidy et al., 2017; Jelleyman et al., 2015; Batacan Jr. et al., 2016).

Although HIIT has been considered an alternative time-efficient treatment strategy, specific equipment (i.e. cycle ergometer and treadmill), commonly required by most HIIT protocols studied, are found only in physical activity facilities (i.e. gymnasiums) and they are expensive. A lack of local facilities to do physical exercises (Korkiakangas et al., 2009a) and money, especially in developing countries (Reichert et al., 2007), are important barriers for people to be able to comply with guideline recommendations. Hence, alternative HIIT protocols performed with body weight have recently been studied (Allison et al., 2017a; Gist et al., 2014a; Williams & Kraemer, 2015). For instance, Allison et al. (2017a) and Gist et al. (2014a) showed that high-intensity interval body weight training (HIBWT) promoted similar cardiorespiratory fitness adaptations to traditional HIIT on cycle ergometer in young. Thus, it would seem reasonable to assume that HIBWT is an efficient alternative strategy to traditional HIIT.

To the best of our knowledge, no previous studies have measured the HIBWT effectiveness in bringing about changes in body composition, inflammatory markers, IR and physical performance in older adults, especially in PW. The present study was designed to test whether HIBWT is a better exercise strategy when compared to COMT for PW at high risk of TDM2. To test this hypothesis, we compared the effects of an HIBWT with the effects of a COMT on body composition, physical performance and inflammatory and IR markers in PW at high risk of TDM2.

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