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RESEARCH

Cycle ergometer high-intensity interval training does not produce a transient risk of falling in adults 50–70 years of age

Christopher James Keating[1,2,3] · Juan Antonio Párraga-Montilla[2] · Pedro Ángel Latorre-Román[2] · Paul T. Donahue[1]

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Abstract

Purpose High-intensity interval training (HIIT) is an exercise routine that induces positive physiological adaptations. However, research has stated that HIIT may elicit a fall risk. Therefore, does a single session of cycle ergometer HIIT negatively affect postural control differently from that of metabolically matched moderate-intensity continuous training (MICT)?

Methods Twenty adults participated in non-weight-bearing cycling on two separate days, one HIIT and the other MICT. Prior to exercise, baseline measures of center-of-pressure (COP), gait, and dynamic balance were acquired. The same measures were captured at four (4) time points post-exercise (immediately, 10-, 20-, and 30-post). COP data were collected for double-leg eyes closed (EC) and single-leg eyes opened (SL) scenarios in two directions (anterior–posterior [AP] and medial–lateral [ML]).

Results No significant differences for condition (HIIT vs MICT) or condition x time (pre, post, 10, 20, and 30) were observed. Significant time effects for sway velocity in AP-SL ($p = 0.002$) and ML-SL ($p = 0.023$) and significant differences for time in sway range ML-EC ($p = 0.003$) were observed. There was a significant effect for time in gait velocity ($p = 0.018$).

Conclusion A single session of cycle ergometer HIIT does not negatively affect postural control compared to a metabolically matched MICT protocol. HIIT does not impede postural control determined by COP data. Total work performed and individual training status may better indicate adverse changes in postural control variables in adults aged 50–70 years.

Keywords Postural control · Center of pressure · Balance · Gait · Fall risk

Introduction

According to the United Nations, by 2050, the world's population ≥ 65 years of age is projected to double. This trend is no longer a concern affecting only developed countries but is now a global phenomenon affecting all. The rise of the aging population brings an increased cost to society because the number of working-age individuals declines relative to the total number of consumers. Furthermore, the progressive decline of functional capacity throughout life is associated with diminished gait and balance parameters. Muscle mass is reported to deteriorate after age 50 by approximately 2% each year [1]. Preventing and/or delaying this loss can help prevent accidents caused by falls that regularly lead to hospitalizations, costly medical care, and premature death in older adults. Therefore, we must focus on emerging efforts such as physical activity to age well and minimize the loss of functional capacity.

A growing body of evidence confirms that physical activity is associated with increased functional health, a lower risk of falling, better cognitive function, and lower rates of non-communicable chronic disease [2]. A recent study found that physical activity is associated with a lower mortality risk and that health policies for aging adults should include exercise as one of the main objectives [3]. Therefore, we can and should consider physical activity an anti-aging therapy. However, independent of gender and socioeconomic status, adults indicate that a lack of time is a significant barrier limiting their participation in physical activity [4].

✉ Christopher James Keating
cjames@ucam.edu

[1] School of Kinesiology & Nutrition, University of Southern Mississippi, Hattiesburg, MS, USA

[2] Department of Didactics of Corporal Expression, Universidad de Jaén, Jaén, Spain

[3] Facultad de Deporte, Universidad Católica San Antonio de Murcia, Campus de los Jerónimos, Guadalupe, 30107 Murcia, Spain

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High-intensity interval training (HIIT) is an exercise protocol that induces many physiological adaptations to improve health outcomes when compared to a moderate-intensity continuous training (MICT) protocol [5]. The advantage of HIIT is that it maximizes efficiency while minimizing the time invested [6]. HIIT has also been recognized as a suitable exercise regimen for chronic disease patients due to its positive effect on cardiorespiratory fitness and metabolic function [7, 8]. A recent systematic review found that HIIT was well-tolerated in an older population with divergent comorbidities and effectively increased cardiorespiratory fitness [9]. More recent research has also concluded that HIIT is safe and effective at improving lower limb strength and dynamic balance in aging adults [10, 11]

However, numerous articles have stated that HIIT may present a "fall window" where the participant may be at a greater risk of falling due to impaired balance [10, 12–14]. Those papers cite one (1) publication as the justification for why there is an increased risk of falling due to participation in HIIT. Donath et al. (2015) suggest that a single session of HIIT can elicit an elevated transient risk of falling, and the time efficiency of HIIT could be debated if, indeed, a "fall window" is present [15]. The research compared two exercise interventions, a 4 × 4 min HIIT session and a moderate-intensity walking session (control) performed on a treadmill. Although the study indicates that HIIT and control were equal in time, the recovery periods for the control group were passive, and the HIIT protocol used active recovery periods.

Furthermore, the speed at which the participants walked was not equal among the two interventions, which, in turn, did not present an "apples-to-apples" comparison. Nevertheless, the study concluded that HIIT produces a greater risk of falling in older adults over 65, although the two interventions were not similar. Therefore, the current study's authors believe that the only research indicating that HIIT produces an elevated fall risk may be misleading due to the lack of equality in the total work performed, age of participants, and modality used.

However, the results from Donath et al. (2015) are appealing and have highly influenced scientific literature, cited in over 40 publications. Scientific journals more often publish novel, positive, statistically significant results compared to results that replicate previous studies, negative findings, or confirm the null hypothesis. Only publishing significant findings results in publication bias that emphasizes the positive results and does not paint a complete picture of the genuine state of research [16]. It is, therefore, essential and necessary to replicate critical findings, like those found by Donath et al. (2015), but to include new elements that may have been shortcomings/limitations of the previous research to test further the underlying theory [17].

Consequently, this research aims to determine if a single session of cycle ergometer HIIT negatively affects balance and gait parameters in adults 50–70 years of age and, if so, is it different from that of a metabolically matched protocol (MICT). Unlike the research by Donath et al. (2015), the current study will focus on cycle ergometer exercise, the most often utilized modality for HIIT interventions in an aging population [9, 18]. The current research will also focus on a younger population (50–70 years of age) that most needs exercise interventions to combat the onset of chronic disease diagnosis [19]. Lastly, the two interventions will be metabolically equal (work matched) to present a fair comparison of the effects of the two exercise interventions. The authors hypothesize that there will be no significant differences in balance or gait parameters if the exercise interventions are metabolically matched.

Methods

Study design

The present study was designed as a within-subjects repeated measure (2 × 5) randomized cross-over study. The order of the two exercise conditions (HIIT and MICT) was randomly assigned for each participant. The repeated measure for time (pre, post, 10 min post, 20 min post, and 30 min post) remained constant for both the conditions. The two exercise assessment days were separated with a recovery period of at least 48 h but no more than 7 days.

The local (institutional) ethics committee approved the study and complied with the 2013 Declaration of Helsinki. All participants signed informed written consent prior to the start of data collection.

Participants

Sample size estimation was conducted using a conventional $\alpha = 0.05$, $\beta = 0.80$, and partial eta-squared moderate effect size of 0.06 for a repeated measure within and between subject design (2 conditions × 5 time points) produced a calculated sample of 20 participants, similar to previous investigations [15, 20]. Therefore, twenty adults 50–70 years of age (age = 58.2 ± 6.93; 10 males, 10 females) were recruited from the local community and were enrolled in the study. No participant reported using prescribed medication or other health impairments that may have adversely affected gait and balance. All participants were asked to refrain from strenuous exercise 48 h before testing and to maintain uniformity between the two testing days (including the same/similar testing time).

Before the first exercise intervention, participants resting heart rate (RHR), height, weight, and body composition

were assessed. RHR was evaluated after 5 min in the seated position with a non-invasive fingertip pulse oximeter. Height was measured in centimeters with a freestanding stadiometer with a digital display. Weight and body composition were determined using multifrequency bioimpedance analysis (BIA). Body mass index (BMI) was calculated as weight divided by height squared ($\frac{kilograms}{meters^2}$).

Interventions

Subjects participated in non-weight-bearing electronically braked cycle ergometer (Velotron, RacerMate/SRAM, Chicago, IL) exercise under the supervision of an exercise specialist who was present for all sessions. Exercise intensities were prescribed based on the Tanaka maximal heart rate (HRmax) prediction equation [21]. The specialist observed the heart rate response throughout the protocol and adjusted the power output to achieve the desired intensity range. The participant's heart rate (HR), rate of perceived exertion (RPE), and watt production were logged during each interval. The participants' bike position was set and recorded in the first session and remained constant throughout. The participants were instructed to maintain steady yet constant revolutions per minute (RPM). The Velotron software recorded in real time for posterior analysis and data confirmation.

High-intensity interval training (HIIT)

HIIT intervention was the 4 × 4 method most often used in cardiovascular disease patients [22]. The intervention consists of 4 × 4-min intervals at 85–95% of maximal heart rate (HRmax), followed by 4 × 3-min active recovery periods at 60% of HRmax. A 5-min warm-up (50–60% of HRmax) was included in the exercise session, which lasted for 33 min.

Moderate intensity continuous training (MICT)

MICT intervention consisted of a continuous intensity (60–70% of HRmax) for 37 min. Identical to the HIIT protocol, a 5-min warm-up (50–60% of HRmax) was included in the exercise session, amassing 42 min.

Testing procedures

Center-of-pressure (COP) data from a single force platform (AMTI, Watertown, MA) were acquired at 120 Hz using a fixed, below-ground system. The COP trace was separated into medial/lateral (ML) and anterior/posterior (AP) components. Two postural sway measures were computed from the COP data in the ML and AP directions: (1) sway range and (2) sway velocity. Postural sway measures were calculated using similar equations as those previously reported by Bailey et al. [23].

The battery of tests consisted of the double-leg eyes closed (EC) and single-leg eyes opened (SL) scenarios, and the order for individual participants remained constant. However, the order of the scenarios per participant was assigned rotating to minimize the possible effect of order bias. Before data collection, the investigators determined the participants' dominant foot by rolling out a ball and asking them to kick it back to the investigator. The foot that dominated the ball was identified and used for the SL scenario. Participants were then shown the proper platform position and stance for each scenario. Before starting and between conditions, the participants were asked to reposition themselves to their original stance, respectively. The participants were accessed with tennis shoes on, and the same pair was worn for both days. Each measure was recorded for 10 s, and the average of two trials was used for data analysis.

A 10-m walk test assessed gait velocity. The intermediate 6 m was timed to allow acceleration in the first 2 m and deceleration in the last 2 m. The time was measured using a wireless electronic timing system (Dashr Systems, Lincoln, NE) and transmitted via Bluetooth to a handheld device. The participant's comfortable, preferred walking speed was used. Two measures were taken at each of the five time points, and the average of the two measures was used for data analysis.

The standardized timed up-and-go (TUG) test assessed dynamic balance and agility. The participant was cued by a countdown (ready, set, go), a timer was initiated at the word go, and the participant started moving; the time stopped when the participant sat back down in the chair. This test was measured in seconds and rounded to the nearest one-hundredth (i.e., 0.00) [24].

Statistical analysis

All variables are expressed as a mean and standard deviation (M ± SD) and were analyzed using the statistical package SPSS v. 27 (SPSS Inc., Chicago, IL, USA). The two exercise modes were compared using a paired samples t-test. Due to data file corruption, COP data were analyzed for 18 participants, whereas all other data were analyzed with 20 participants. Normality assumption by Shapiro–Wilks was identified for each variable, and normality was assumed. COP, gait, and agility measures were analyzed as within-subjects 2 (condition: MICT and HIIT) by 5 (repeating factor of time: pre, post, 10-post, 20-post, 30-post) repeated measures analyses of variance (ANOVA). When sphericity was not met, the Greenhouse–Geisser correction was observed. Bonferroni post hoc tests were calculated if there was a significant condition and/or time effect. The effect size of partial eta squared (ηp^2) was calculated for the repeated measures ANOVA to determine the practical importance. The authors interpret a ηp2 as ≥ 0.01 small, ≥ 0.06 medium, and ≥ 0.14

Table 1 Participant descriptive statistics

	Total (N = 20)	Males (N = 10)	Females (N = 10)
Age (years)	58.2 ± 6.93	56.7 ± 7.47	59.7 ± 6.38
Height (cm)	171.29 ± 12.37	182.18 ± 5.88	160.40 ± 4.97
Weight (kg)	69.58 ± 14.20	79.19 ± 8.84	59.96 ± 11.92
BMI (kg/m^2)	23.5 ± 3.23	23.8 ± 2.54	23.2 ± 3.91
FM (%)	22.13 ± 8.73	16.31 ± 4.77	27.96 ± 7.93
RHR (bpm)	65.9 ± 8.3	67.3 ± 7.2	64.5 ± 9.46

Expressed as mean ± standard deviation, *BMI* body mass index, *FM* fat mass, *RHR* resting heart rate

Table 2 Exercise intervention comparison

	HIIT (N = 20)	MICT (N = 20)	*p*
Watts Total	121.77 ± 43.79	92.54 ± 34.41	**< 0.001**
High	*167.36 ± 68.40*		
Low	*65.32 ± 25.00*		
HR Total	129.48 ± 12.86	116.00 ± 16.72	**< 0.001**
High	*151.58 ± 8.24*		
Low	*121.56 ± 10.47*		
RPE Total	12.16 ± 1.34	10.92 ± 1.79	**0.001**
High	*14.56 ± 1.51*		
Low	*10.40 ± 1.80*		
RPM	78.81 ± 7.01	78.88 ± 6.90	0.945
Kilocalories	242.95 ± 87.48	234.41 ± 87.18	0.519

Bold statistical significance at or below alpha of 0.05

High mean of high-intensity intervals, *Low* mean of low-intensity intervals, *RPE* rate of perceived exertion, *RPM* revolutions per minute, *HR* heart rate.

large [25]. Significant differences were established using an a priori alpha level of $p < 0.05$.

Results

Descriptive demographical and anthropometrical data are displayed in Table 1. Twenty participants completed both exercise sessions with an average age of 58.2 years ± 6.93. Exercise comparisons are displayed in Table 2. The two exercises were metabolically matched, as demonstrated in the amount of energy expended in kilocalories (kcal) at 242.95 ± 87.95 for HIIT and 234.41 ± 87.18 for MICT ($p = 0.519$).

No significant difference for condition (HIIT vs. MICT) or condition x time (pre, post, 10-post, 20-post, and 30-post) effects were found for all outcome variables shown in Table 3 and depicted in Fig. 1. However, significant time effects were found for sway velocity in the AP-SL (F [4] = 4.78, $p = 0.002$, $\eta_p^2 = 0.23$) and ML-SL (F [2.69] = 3.65, $p = 0.023$, $\eta_p^2 = 0.186$) positions and significant difference for time in sway range in the ML-EC (F [4] = 4.52, $p = 0.003$, $\eta_p^2 = 0.21$) position. There was also a significant effect for time in gait velocity (F [1.86] = 4.66, $p = 0.018$, $\eta_p^2 = 0.197$) (Table 3).

Post hoc testing revealed that the effect for time in sway velocity for the AP-SL position was significantly different between pre to 30-post ($p = 0.013$), post to 20-post ($p = 0.014$), post to 30-post ($p = 0.002$), and 10-post to 30-post ($p = 0.002$). Effect for time in sway velocity for the ML-SL position was significantly different between pre to 20-post ($p = 0.01$),

Table 3 Within-subjects effects for condition, time, and condition x time

	Condition			Time			Condition x Time		
	F	*p*	η_p^2	F	*p*	η_p^2	F	*p*	η_p^2
Sway velocity									
AP-EC	1.766	0.201	0.094	1.460	0.224	0.079	0.976	0.402	0.054
AP-SL	2.025	0.174	0.112	4.777	**0.002**	0.230	0.254	0.825	0.016
ML-EC	1.330	0.265	0.073	2.621	0.070	0.134	1.415	0.238	0.077
ML-SL	0.729	0.406	0.044	3.648	**0.023**	0.186	0.880	0.481	0.052
Sway range									
AP-EC	0.812	0.380	0.046	1.126	0.313	0.062	1.080	0.324	0.060
AP-SL	0.001	0.971	0.000	0.922	0.418	0.055	0.864	0.438	0.051
ML-EC	0.501	0.489	0.029	4.518	**0.003**	0.210	1.870	0.147	0.099
ML-SL	0.162	0.693	0.010	1.195	0.322	0.069	1.460	0.225	0.084
Gait and agility									
Velocity	0.243	0.628	0.013	4.664	**0.018**	0.197	1.054	0.370	0.053
TUG	0.246	0.626	0.013	0.292	0.754	0.015	0.112	0.938	0.006

Bold statistical significance at or below alpha of 0.05

AP anterior–posterior, *ML* medial–lateral, *EC* eyes closed, *SL* single leg, *TUG* timed up and go.

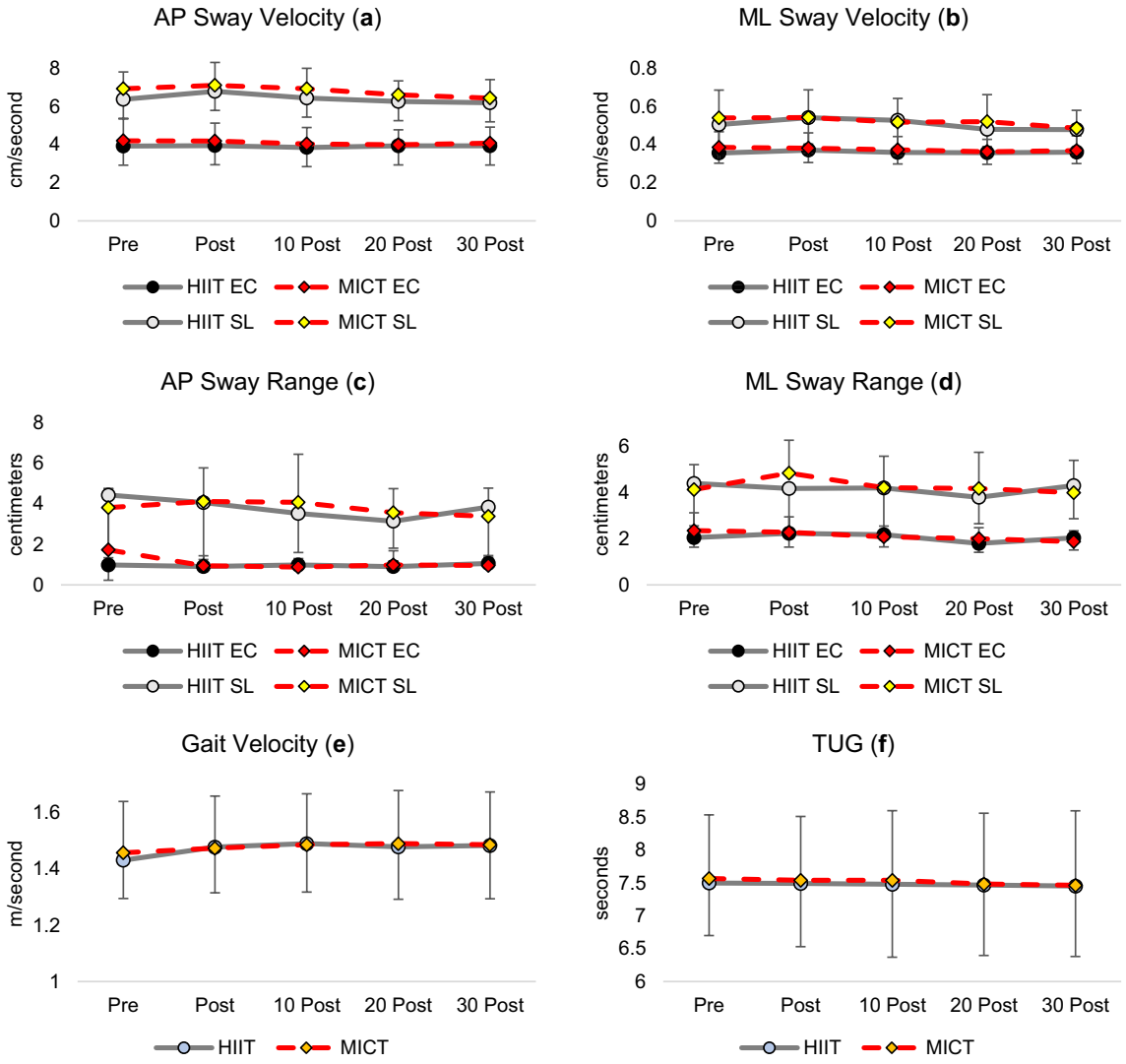

Fig. 1 Within-subjects postural control, dynamic balance, and gait velocity measures over time. COP sway velocity (**a** = AP, **b** = ML), sway range (**c** = AP, **d** = ML), gait velocity (**e**), and TUG (**f**) data for both HIIT and MICT exercises. COP data in the EC and SL conditions are represented on the same graphs (**a–d**). No significant difference for condition or condition x time interactions was found

pre to 30-post ($p = 0.007$), post to 30-post ($p = 0.003$), and 10-post to 30-post ($p = 0.011$). Effect for time in sway range for the ML-EC position was significantly different between pre to 20-post ($p = 0.016$), post to 20-post ($p = 0.001$), post to 30-post ($p = 0.012$), 10-post to 20-post ($p = 0.029$). Effect for time in gait velocity was significantly different between pre to post ($p = 0.011$), pre to 10-post ($p = 0.001$), pre to 20-post ($p = 0.029$), and pre to 30-post ($p = 0.026$).

Discussion

The primary objective was to determine if a cycle ergometer HIIT exercise induced a transient effect on postural control variables in adults and if the effect differed from that of a metabolically matched MICT protocol. According to the current data, metabolically matched cycle ergometer HIIT and MICT protocols do not significantly affect balance or gait parameters in healthy adults 50–70.

Compared to the MICT protocol, there were no differences in the postural control measures. Furthermore, there were no significant adverse differences between pre- and post-intervention. These data suggest no transient "fall window" for HIIT or MICT in healthy adults aged 50–70 years. However, the authors acknowledge that the current data do not support what is commonly found in the scientific literature. A systematic review by Helbostad et al. (2010) found that balance is impaired due to resistance exercise-induced fatigue but that the rate of fatigue and recovery from that fatigue varied greatly among research studies [26]. Hill et al.

(2015) compared the effects of treadmill walking, cycling, and arm-crank ergometry (50% of heart rate reserve) on postural sway in healthy older females (age = 70.2 ± 7.8 years) and found that cycling and treadmill walking, but not arm-crank ergometry, impaired postural stability that lasted approximately 10 min [27]. Research by Stemplewski et al. (2012) examined the effect of moderate-intensity cycling on postural sway in older males (age = 68.4 ± 2.9 years) and determined that there was a difference between pre- and post-exercise sway velocity and that older males should be cautioned of a temporary increase in "fall risk," however, this study included no exercise comparison group (no exercise and exercise). That same study concluded that changes in postural control may be more related to an individual's body mass index and the level of fatigue as indicated by blood lactate levels [20]. Based on the research mentioned above, it is apparent that pre- to post-exercise changes to postural control can occur but that the total work performed or rate of individual fatigue may be the most important indicator of possible postural control impairments post-exercise. However, few studies have examined the acute effect of HIIT exercise on postural control variables, and to our knowledge, none have compared the effect of cycle ergometer HIIT to that of a metabolically matched (equalized work) protocol (MICT). The current study's authors believe that more research needs to be done to determine alternative ways of explaining the complexity of the matter.

The study by Morrison et al. (2016) indicated that significant changes to postural control only arise in participants over the age of 70, and those changes were the result of walking and/or resistance training-induced fatigue [28]. The study by Hill et al. (2016) conducted in younger adults (age = 20.1 ± 2.6 years) did not compare HIIT with MICT but determined that HIIT produced a transient postural control change lasting 10 min that was attenuated with just 6 weeks of training, indicating that training status may be a better predictor of postural control changes [29]. The current research presented data from a healthy (BMI = 23.5 ± 3.23, RHR = 65.9 ± 8.3) yet aging population (58.2 ± 6.93). Although this population is reportedly active and healthy, to the best of our knowledge, it is the first study that compares cycle ergometer HIIT to metabolically matched (apples-to-apples) MICT to determine if HIIT is producing the change or if it is merely the amount of work performed in the exercise bout, regardless of intensity. These data demonstrate that two different, yet work-equalized, cycle ergometer interventions do not produce significantly different postural control changes.

Interestingly, the differences in the HIIT protocol indicated slight improvements in gait and balance parameters, and gait velocity significantly increased post-HIIT and MICT. A study by Helbostad et al. (2007) noted a similar increase in gait velocity post-exercise in which they attributed the increase to movement pattern changes to cope with fatigue caused by walking [30]. However, the current data did not find any difference in the postural control variables post-exercise, and thus, the authors believe that the rise in gait velocity in this research could be attributed to the higher cycling cadence, which led to a higher walking cadence post-exercise. Recent research by Keating, Hester, and Thorsen (2024) studied the connection between cycling cadence, work rate, and gait velocity in healthy college-age students without neurodegenerative disease [31]. That research determined that the increase in gait velocity post-cycling can be attributed to the increase in cycling cadence above their respective gait cadence, but not an increase in work rate. A systematic review by Santos et al. (2019) found a similar increase in gait velocity post-exercise, but the evidence was inconclusive as the results were heterogeneous [32]. That same review suggests another explanation could be that a "warm-up" rather than an interference effect might have occurred. If that were true, the increase could be due to post-activation potentiation, and the exercise intended to cause fatigue created a pre-condition that increased muscle activation post-exercise. Further research should investigate the source of the increased gait velocity phenomena.

The authors of the current study want to be very clear in stating that we do not believe that the Donath et al. (2015) research is unfounded, but rather, more research needs to be done to determine what is the cause of postural control variable changes in varying populations and conditions. Unlike the research by Donath et al. (2015), the current study investigated the effects of cycle ergometer exercise in an active and healthy aging (50–70 years of age) population. The current research has provided insight into the possible drivers of change in postural control variables. As the two exercise interventions were metabolically matched and no significant differences in postural control variables were noted, it suggests that HIIT is not the primary cause of change. However, it may be more connected with the increased work rate or metabolic cost above an individually determined specific value or level. Further research should be done to identify the complexities of postural control changes with varying exercise conditions and populations.

Nevertheless, the authors of the current study understand that it does not come without its limitations and believe it has three primary constraints that should be addressed. First, the current population of adults does not represent an at-risk or fall-prone population. While the participants are not fall-prone, their age is aligned with the average age of individuals entering cardiac rehabilitation in various countries, as noted by the INTERheart study [33]. This is important because cycle ergometer HIIT protocols are becoming more common for chronic disease populations in rehabilitation programs across the globe [9, 22, 34]. Nevertheless, the current data are representative

of the population needing exercise interventions such as HIIT to reduce the impact of chronic disease/disability, and it is the population age range stated in the literature as being the most prevalent to use HIIT as an exercise intervention [10] or needing different interventions to combat the onset of chronic disease in the future [19].

Second, substantial variations in postural sway procedures and calculations make it challenging for COP data to be compared across various studies. The current research followed a strict regimen of procedures; however, it was not until data processing that the authors realized that slight balance corrections by the individual (i.e., toe tap, foot shift) made for significant variations in the average postural sway calculations, mainly sway range in the SL condition. This is a concern not only with the current research but among most research utilizing postural sway data, where factors such as foot placement can affect the variables [35, 36]. Future research should use three or more trials to decrease the likelihood of unnecessary variance due to balance correction techniques, use longer balance durations on the platform, and the stance should be standardized, as suggested in a recent review [35].

Third, exercise was prescribed using an age-adjusted prediction equation [21], possibly leading to incorrect intensity targeting as the individual's actual maximal heart rate was never accessed. However, this study does not focus on the exact exercise intensity per se but on the COP values after a HIIT session (90% HRmax) vs. a MICT (60% HRmax) session. For this reason, the authors believe this limitation could have led to incorrect individual exercise intensities. However, the high versus moderate exercise integrity remains intact because the prediction equation was used to control exercise intensity for the HIIT and MICT sessions. Furthermore, a recent publication concluded that HRmax can be utilized to prescribe cycle ergometer HIIT in an older adult population and that the prescription becomes even more appropriate when combined with RPE, as we have done in the current research [11].

The authors believe the current research has a straightforward yet practical application; neither cycle ergometer HIIT nor MICT produced an elevated risk of falling, identified by COP values, in apparently healthy adults 50–70. Postural control variables assessed by COP are limited and may not justify definite fall risk in a healthy adult population. HIIT exercise has been shown to produce positive physiological changes, and adults aged 50–70 years should not be discouraged from participating in HIIT due to the speculation of adverse changes to postural control variables when the world population is suffering from chronic diseases caused by sedentary behavior and physical inactivity. When used correctly, HIIT can improve cardiovascular health and lower limb strength while being time efficient [9, 11, 37, 38].

In conclusion, a single session of cycle ergometer HIIT does not produce an acute transient effect on postural control or gait parameters in adults aged 50–70 years. The current data demonstrate that when compared to metabolically matched MICT, HIIT is equally effective yet more time efficient. Both HIIT and MICT produced a slight increase in gait velocity post-exercise that the authors believe is due to an increased pedaling cadence that bled into the walking cadence immediately post to 10 min post-exercise. HIIT alone does not affect postural control variables as measured by COP data. Total work performed and individual training status may better predict adverse changes in postural control variables. Future research must investigate the effects of various workloads further to explain their effects on postural control measures. HIIT should not be singled out as a hazardous exercise intervention for healthy adults 50–70 years of age when the world's aging population is growing ever faster and needs more effective yet time-efficient exercise regimens like cycle ergometer HIIT that help prevent the loss of functional capacity and increase both cardiovascular and metabolic fitness.

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Data availability The data that support the findings of this study are available on an individual basis by contacting the corresponding author directly.

Declarations

Conflict of interest The authors declare no competing interests.

Ethical approval Study approval statement: The local university ethics committee approved the study.

Consent to participate All the participants were informed of the study procedure, protocols, and risks involved in participation; participants were allowed to express their concerns and ask any questions. Afterward, the participants signed informed written consent forms before starting the data collection process.

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