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Effect of concurrent resistance and sprint training on body composition and cardiometabolic health indicators in masters cyclists

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In older previously sedentary individuals endurance training imposes a more effective stimulus to enhance cardiometabolic health compared with resistance or sprint training. We examined the effect of replacing a portion of endurance training with combined resistance and/or sprint training and how this influences cardiometabolic health indicators in masters endurance cyclists. Twenty-seven well-trained male road cyclists (53.7 ± 8.2 years) were allocated to a resistance and track sprint-cycling training group (RTC, n = 10), an endurance and track sprint-cycling group (ETC, n = 7) or a control endurance group (CTRL, n = 10). Both the RTC and ETC groups completed a 12-week intervention of specific training while the CTRL group maintained their endurance training load. Lower limb lean mass (LLM), trunk fat mass (TFM), fasting blood glucose (FBG), total cholesterol (TC), triglycerides (TG), systolic blood

pressure (SBP), and diastolic blood pressure (DBP) were measured before and after the intervention period. TFM decreased for all groups ($P < 0.05$) while LLM significantly increased for RTC and ETC groups ($P < 0.05$). No significant between group or time effects were observed for FBG, TC, TG, SBP, or DBP. The results suggest that replacing a portion of endurance training with 12 weeks of ETC or RTC training favourably affects body composition by lowering TFM and increasing LLM without negatively affecting cardiometabolic health indicators in well-trained masters endurance cyclists.

Keywords: Aging, Resistance training, Cycling, Blood pressure, Blood lipids


INTRODUCTION

Normal aging is typically associated with unfavourable changes in serum lipids and blood pressure levels, both of which increase the risk of cardiometabolic diseases such as atherosclerotic vascular disease and type 2 diabetes (Buitrago-Lopez et al., 2011). However, these negative changes in the metabolic profile are determined not only by biological aging itself but also lifestyle factors such as lack of exercise and a poor diet (Gaesser et al., 2011).

Previous studies suggests that resting blood pressure of middle-aged and older endurance runners are at optimal levels ($< 120/80$ mmHg) and lower than in both age-matched strength

and sprint athletes (Kusy and Zieliński, 2015) and inactive controls (Buyukyazi, 2005; Cornelissen et al., 2009; Hernelahti et al., 2002). Moreover, previous studies have shown lower blood glucose, total cholesterol (TC), and triglyceride levels in older endurance-trained athletes than age-matched non-athletic controls (Mikkelsen et al., 2013). Taken together, these data suggest endurance training may explain the lower blood pressure and lower blood lipid levels observed in older endurance athletes.

Despite the widely known performance and cardiometabolic benefits of endurance training, previous research has reported masters athletes involved in non-weight-bearing endurance sports such as cycling and swimming have lower bone mineral density

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compared with other athletes and even nonactive controls (Nichols et al., 2003; Rector et al., 2008). As a result of these findings, masters endurance cyclists may need to incorporate resistance training into their endurance training regimes to maintain optimal bone density as they age (Bolam et al., 2015; Hinton et al., 2015). In addition to resistance training, many road cyclists also incorporate high intensity sprint training to further improve road cycle-racing race performance where ‘attacks’ during a road race and sprint finishes are major factors in successful road cycle-racing. However, it is possible that replacing a portion of endurance training with strength or sprint training may lead to a reduction in endurance training volume which may negatively affect the cardiometabolic profile of masters road cyclists. Indeed, previous research has shown that reductions in endurance training volume lead to increased cardiometabolic risk in both younger runners (Sutherland et al., 1981) and masters cyclists (Giada et al., 1995). In contrast, recent evidence suggests that positive metabolic and musculoskeletal adaptations in healthy older adults occur from short-term resistance and sprint training if the intensity of that training is high (Bell et al., 2015; Nederveen et al., 2015). Therefore, the purpose of this study was to determine if replacing a portion of endurance training with combined resistance and sprint training or sprint training alone will negatively affect cardiometabolic health indicators in masters endurance cyclists.

MATERIALS AND METHODS

Participants

The study was approved by the Central Queensland University Human Research Ethics Committee. Twenty seven male masters endurance cyclists (53.7 ± 8.2 years) with no background of resistance training were recruited and provided written informed consent. The subjects were required to be involved in regular cycling training and competition for a minimum of 2 years and to be achieving a minimum of 8 hr of endurance cycling training per week. All subjects underwent pre-exercise screening to ensure they had no established cardiovascular, metabolic or respiratory disease (nor) signs (or) symptoms of these conditions (Norton, 2005).

Random allocation of participants into training groups was not possible as a result of the majority of participants having both work and family commitments that limited their availability to participate in the RTC or ETC training programs. As a result, subjects were allocated to either a control group (CTRL, $n = 10$), an endurance and track sprint-cycling group (ETC, $n = 7$) or resistance and track sprint-cycling training group (RTC, $n = 10$) based

Table 1. Physical characteristics and training hours per week of the groups

Variable	RTC group (n=10)	ETC group (n=7)	CTRL group (n=10)
Age (yr)	53.5±9.3	49.4±4.8	56.9±8.6
Stature (m)	1.80±0.1	1.80±0.1	1.75±0.1
Body mass (kg)	81.9±6.1	78.5±6.1	83.5±10.0
Training hours (hr/wk)	8.2±1.0	8.1±1.3	8.0±1.2

Values are presented as mean ± standard deviation.

RTC, resistance and track sprint-cycling group; ETC, endurance and track sprint-cycling group; CTRL, control endurance group.

on their availability. Participants were encouraged and agreed to avoid changes in their diet or lifestyle over the intervention period. The physical characteristics of each group are shown in Table 1.

Protocol

Subjects attended the laboratory following an overnight fast and did not consume caffeine the morning of the testing sessions carried out between 07:00 a.m. and 09:00 a.m. hr. Pre- and post-intervention testing included, in order, anthropometric measures, Dual energy X-ray absorptiometry (DEXA), fasting blood glucose (FBG), fasting blood lipids, resting blood pressure and determination of peak aerobic power (VO_{2peak}) on a cycle ergometer. All measurements were performed by the same trained observer.

Anthropometry measures

Stature (m) and body mass (kg) were measured with a stadiometer and medical scales (Seca, Birmingham, UK) with participant's unshod and wearing cycling apparel.

DEXA scanning

DEXA (Hologic Discovery-W, Bedford, MA, USA) was used to measure trunk fat mass (TFM) and lower limb lean mass (LLM). A single trained DEXA technician performed all DEXA measurements. The trunk region consists of the area bordered by a horizontal line below the chin, vertical borders lateral to the ribs and oblique lines passing through the femoral necks. The leg region includes all tissue below these oblique lines.

Blood measures

Subjects were required to fast for 8 hr prior to the blood tests. FBG, TC, and triglycerides (TG) were measured via a 30- μ L capillarized blood sample taken from each subject's fingertips. For the analysis of FBG, TC, and TG a sample of whole blood was collected into a capillary pipette and applied to the Reflotron reagent strip (Roche Diagnostics, Sydney, Australia). Blood samples were processed using a Reflotron Plus reflectance photometer (Hoffman

La Roche Ltd., Basel, Switzerland). Coefficient of variation for FBG is 2.5%, TC is 1.2%, and TG is 2.9% (Roche Diagnostics, Sydney, Australia).

Resting blood pressure

Resting blood pressure was measured upon arrival at the laboratory and after the subjects had undertaken 10 min of seated rest in quiet and comfortable conditions. Blood pressure was measured using a standard mercury hand held sphygmomanometer (Nova-Presameter, Riester, Jungingen, Germany) using the standard guidelines established by the American Heart Association (Perloff et al., 1993). Blood pressure was obtained in triplicate for both arms and each measurement was separated from the next by a 1- to 2-min resting period. The blood pressure obtained from the arm with the highest reading was used for statistical analysis.

VO_{2peak}

A graded maximal exercise test to measure VO_{2peak} was completed on an electrically-braked, computer controlled cycle ergometer (Velotron Dynafit Pro, RaceMate, Seattle, WA, USA). Gas analysis was undertaken using a Fitmate Pro (Cosmed, Rome, Italy) (Brisswalter and Tartaruga, 2014) following a 5-min warm-up at 30-W cycling and a pedalling cadence of 90 rpm throughout the test. The work increments for each one-minute stage were 15 W. The test ceased when no significant increase in O₂ uptake with an increase in work rate and/or volitional exhaustion (Schell and Leelarthaepin, 1990). The test was followed by a 5-min cool down at a self-selected intensity and cadence.

Endurance and track sprint-cycling program

Both RTC and ETC groups replaced two of their usual weekly endurance cycling training sessions with two group track-cycling session per week lasting approximately 90 min, separated by 48 hr. The sprint cycling program was performed in the evening at an outdoor cycling velodrome. The training program was designed in consultation with an accredited track cycling coach and supervised by the same coach for each session. The sprint cycling training sessions consisted of a five to 10-min warm-up of 10–15 laps at a self-selected pace after which subjects performed 1–3 sets × 1–3 repetitions of maximal effort sprints ranging in distance from 65 to 330 m (sprint times ranged from 6 to 30 sec) with 2–3 min of active recovery between repetitions and 10- to 15-min passive rest between sets. At the completion of the track training session subjects performed a 5- to 10-min cool down up of 10–15 laps of the velodrome at a self-selected pace. Selected strategies to

achieve increased maximum speed and acceleration capabilities included 'Over Gear Training' with a gear that is larger than the athlete's typical race gear. Furthermore, the sprint cycling program also incorporated an ascending progressive gear overload method where the gearing size increased progressively following each individual sprint. The overall training adherence rate calculated as a percentage of the total training sessions successfully completed was 87% ± 4% for all sprint cycling training across the 12-week study period with no differences between the RTC and ETC groups.

Resistance training and track sprint-cycling program

The RTC group replaced four of their usual weekly endurance cycling training sessions with two evening group track sprint-cycling training sessions as described above, and two morning gym-based group resistance training sessions per week. All four training sessions were supervised by an accredited strength and conditioning coach. Resistance training sessions were conducted on alternate days to the track sprint training days. During each resistance training session participants completed exercises in the following order: double- and single-leg hopping (2–3 sets of 10–20 hops), box jumps, leg press throws, single-leg leg presses, seated hip flexions, leg curls, leg extensions, seated calf-raises, supine hip extensions, chest presses, bench rows, abdominal curl ups and lower back extensions. Recovery time of 2 min between sets and exercises was strictly controlled with the resistance training sessions lasting approximately 90 min. The progressive resistance training program was periodised to reduce both the potential for overtraining and to optimise neuromuscular adaptation. Subjects completed electronic training logs describing all their training parameters (number of repetitions, sets, loads, track and road training distances, track sprint cycling times) to monitor progress and to provide motivation for maximal effort during the training program. The overall training adherence rate, calculated as a percentage of training sessions successfully completed was 85% ± 4% for track sprint-cycling training and 82% ± 5% for resistance training across the 12-week study period.

Control group

The CTRL group were asked to maintain their normal endurance cycling training for the 12-week intervention period.

Statistical analysis

A three (ETC, RTC, CTRL) × two (pre, post) repeated measures analysis of variance was used to contrast dependent variables of in-

Table 2. DEXA, fasting blood glucose, blood lipids and VO_{2peak} changes in RTC, ETC, and CTRL groups following the 12-week intervention

Variable	RTC group (n = 10)			ETC group (n = 7)			CTRL group (n = 10)		
	Pre	Post	Change (%)	Pre	Post	Change (%)	Pre	Post	Change (%)
TFM (kg)	7.7±2.7	7.3±2.1	-5.1	6.7±1.1	6.0±0.9	-10.4	8.7±1.1	8.5±1.3	-2.2
LLM (kg)	17.4±1.8	18.0±2.3 ^{a)}	3.4	17.0±1.5	17.6±1.4 ^{a)}	3.5	16.0±2.0	16.0±1.9	0.0
FBG (mmol/L)	5.1±0.3	5.0±1.2	-2.7	5.3±0.7	4.64±0.9	-12.6	5.1±0.6	5.2±0.8	0.7
TC (mmol/L)	4.2±1.0	3.9±1.1	-7.1	4.7±0.7	4.2±1.2	-10.6	4.8±1.1	4.5±1.6	-6.25
TG (mmol/L)	0.92±0.2	0.90±0.25	-2.2	1.2±0.4	1.0±0.5	-16.7	1.9±1.8	1.6±0.60	-15.8
SBP (mmHg)	122±5.9	119±6.5	-2.4	129±9.0	121±9.3	-6.2	136±12.2	138±21.8	1.5
DBP (mmHg)	79±5.5	78±6.5	-1.2	80±4.1	78±6.9	-2.5	87±7.2	88±5.8	1.1
VO _{2peak} (mL/kg/min)	46.7±9.3	45.6±8.4	-2.3	54.0±10.2 ^{b)}	51.9±7.1	-3.9	36.9±9.2 ^{b)}	38.4±6.9	1.0

Values are presented as mean ± standard deviation.

DEXA, dual energy X-ray absorptiometry; VO_{2peak}, peak aerobic power; RTC, resistance and track sprint-cycling group; ETC, endurance and track sprint-cycling group; CTRL, control endurance group; Change, percentage change from pre to post training; TFM, trunk fat mass; LLM, lower limb lean mass; FBG, fasting blood glucose; TC, total cholesterol; TG, triglycerides; SBP, systolic blood pressure; DBP, diastolic blood pressure.

^{a)}Significant pre to post effect ($P < 0.05$). ^{b)}Significant difference between ETC and control group ($P < 0.05$).

terest. If a main effect was observed, a Tukey *post hoc* test was undertaken to identify the source of the differences. A P -value of < 0.05 was considered to be statistically significant. Cohen conventions for effect size (ES) were used for interpretation where ES = 0.2, 0.5, and 0.8 are considered as small, medium and large, respectively (Cohen, 2013). IBM SPSS Statistics ver. 20.0 (IBM Co., Armonk, NY, USA) software was used for all statistical analyses.

RESULTS

Table 2 shows the changes in each of the variables of interest for each of the groups over the 12-week intervention period.

Trunk fat mass

A significant effect of time was observed for TFM ($P < 0.01$). However, no significant between group effects were observed for TFM ($P = 0.49$) following the exercise training period. ES analysis revealed that 12 weeks of RTC training had no effect on TFM in the RTC group (ES = -0.16) or CTRL group (ES = -0.16). However, 12 weeks of ETC training had a moderate, negative effect on TFM in the ETC group (ES = -0.69). There was no effect on TFM following the exercise training period observed in the control group (ES = -0.16).

Lower LLM

LLM increased significantly in both the RTC group ($P = 0.01$) and the ETC group ($P = 0.01$) with no significant between-group differences observed for LLM ($P = 0.89$). Twelve weeks of RTC training had a small effect on LLM in the RTC group (ES = 0.29).

In contrast, 12 weeks of ETC training had a moderate effect on LLM in the ETC group (ES = 0.41). There was no effect on LLM following the exercise training period observed in the control CTRL group (ES = 0.00).

Fasting blood glucose

There were no significant effects of time ($P = 0.35$) or between group differences observed for FBG ($P = 0.46$) following the study intervention period. ES analysis revealed RTC training had no effect on FBG in the RTC group (ES = -0.16). In contrast, 12 weeks of ETC training had a large effect (ES = -0.83) on FBG in the ETC group. There was no effect on FBG following the exercise training period observed in the control CTRL group (ES = -0.05).

Total cholesterol

There were no significant effects of time ($P = 0.06$) or between group differences ($P = 0.82$) observed for TC following the intervention. ES analysis revealed 12 weeks of RTC training had a small effect on ETC in the RTC group (ES = -0.30). In contrast, 12 weeks of ETC training had a moderate effect on ETC in the ETC group (ES = -0.40). There was a small effect on TC following the exercise training period observed in the control group CTRL (ES = -0.21).

Triglycerides

There were no significant effects of time ($P = 0.51$) or between group differences ($P = 0.22$) observed for TG following the study period. ES analysis revealed 12 weeks of RTC training had no effect on TG in the RTC group (ES = -0.08). In contrast, 12 weeks

of ETC had a small effect on TG following 12 weeks of ETC training in the ETC group ($ES = -0.30$). There was a small effect on TG following the exercise training period observed in the CTRL group ($ES = -0.22$).

Blood pressure

There were no significant effects of time ($P = 0.34$) or between group differences ($P = 0.28$) observed for SBP following the study period. ES analysis revealed 12 weeks of RTC training had a moderate effect on SBP following 12 weeks of RTC training ($ES = -0.48$). In contrast, a 12 weeks of ETC had a large effect on SBP following 12 weeks of ETC training in the ETC group ($ES = -0.87$). There was no effect on SBP following the exercise training period observed in the control CTRL group ($ES = 0.11$).

There were also no significant effects of time ($P = 0.32$) or between group differences ($P = 0.43$) observed for DBP following the study period. ES analysis revealed 12 weeks of RTC training had no effect on DBP in the RTC group ($ES = -0.16$). In contrast, 12 weeks of ETC training had a small effect on DBP in the ETC group ($ES = -0.36$). There was no effect on DBP following the exercise training period observed in the control CTRL group ($ES = 0.15$).

VO_{2peak} (peak aerobic power)

There was a significant between group difference in pre VO_{2peak} ($P = 0.01$). Pre VO_{2peak} was significantly greater in the ETC, compared to the CTRL group ($P = 0.01$) (Table 2). There were no significant effects of time ($P = 0.73$) or between group differences ($P = 0.60$) observed for VO_{2peak} following the study period. ES analysis revealed RTC training had no effect on VO_{2peak} in the RTC group ($ES = -0.12$). In contrast, 12 weeks of ETC training had a small effect on VO_{2peak} in the ETC group ($ES = -0.23$). There was no effect on VO_{2peak} following the exercise training period observed in the control group ($ES = 0.18$).

DISCUSSION

Recent evidence suggests that short-duration sprint and/or resistance training may lead to positive adaptations in cardiometabolic risk factors if the intensity of exercise is high (Bell et al., 2015; Kusy and Zieliński, 2015). This evidence supports the long held position that endurance training leads to significant improvements in the cardiometabolic risk profile in previously sedentary older individuals. In the present study we investigated whether the replacement a portion of endurance training by resis-

tance and sprint exercise might influence body composition and cardiometabolic health indicators in endurance-trained masters cyclists. The major finding of the present study was that TFM was significantly reduced in both the ETC and RTC groups. Moreover, 12 weeks of RTC and ETC significantly increased LLM. However, there were no significant changes or between group differences in the important cardiometabolic health indicators of FBG, TC, TG, SBP, or DBP. Therefore, the current data supports the hypothesis that 12 weeks of RTC or ETC will not negatively affect cardiometabolic health indicators in masters endurance cyclists.

TFM is a well-recognised and independent risk factor for cardiometabolic disease (Hu et al., 2011). Thus, the significant reduction in TFM observed in the ETC and RTC groups of the present study suggest the addition of high intensity sprint and/or resistance training may lower the risk of cardiometabolic disease in endurance-trained masters cyclists. Indeed, in the present study, 12 weeks of ETC reduced TFM by 10.4% accompanied by a moderate ES (-0.69). Moreover, the RTC group reduced TFM by 5.1% while the CTRL group reduced TFM by 2.2% (-0.16). These findings are in agreement with earlier findings by Treuth et al. (1994) who reported a significant reduction in TFM following 16 weeks of resistance training performed three times per week in a group of healthy, older males aged 50–75 years. More recently, Sillanpää et al. (2009) also reported a significant reduction in TFM following 21 weeks of combined resistance and endurance training performed four times per week in a group of middle-aged females aged 48.9 ± 6.8 years. However, our study is the first to have investigated the effects of resistance and/or sprint training on TFM in healthy older adults who are also masters athletes. Taken together, the present and previous results suggest ETC training may be more beneficial for reducing TFM than RTC or endurance cycling training alone in masters endurance cyclists.

The present study also observed a significant increase in LLM following 12 weeks of RTC and ETC training. These findings are in agreement with previous studies that have reported significant increases in lean mass in response to a combined resistance and sprint training intervention in masters sprint runners (Cristea et al., 2008; Reaburn et al., 1994). For example, Cristea et al. (2008) reported a significant increase in LLM in a group of sprint-trained male masters sprint runners who completed a 20-week progressive resistance training program. The loss of muscle mass with age is an independent risk factor for cardiometabolic disease (Dominguez and Barbagallo, 2007). Masters athletes, like their sedentary age-matched counterparts are susceptible to an age-related decline in

muscle mass (Reaburn and Dascombe, 2009) which may thus increase their risk of cardiometabolic disease. In the present study, RTC training had a small effect on LLM in the RTC group with a moderate effect on LLM observed in the ETC group. Recent research suggests sprint training may positively affect lean mass in healthy but previously untrained older adults (Bell et al., 2015; Nederveen et al., 2015). Taken together with these previous findings, the present data suggest sprint training may induce muscle hypertrophy in masters athletes which subsequently may reduce the risk for cardiometabolic disease. Moreover, the present findings suggest the increased muscle hypertrophy from augmenting endurance training with sprint or resistance training does not appear to negatively impact on important cardiometabolic risk factors.

In the present study we also examined the effects of 12 weeks of ETC and RTC training on a number of commonly measured cardiometabolic risk factors including FBG, total cholesterol, TG, and blood pressure. In summary, the current data suggests RTC and ETC had no negative effect on any of the cardiometabolic risk factors when an older endurance athlete has a significant volume of their endurance training replaced by either sprint training alone or concurrent sprint and resistance training.

Hyperglycaemia is a widely acknowledged risk factor for cardiometabolic disease (Brunzell et al., 2008). The present study observed that 12 weeks of RTC or ETC did not negatively affect FBG levels in masters endurance cyclists who replaced a significant portion of their normal endurance training with sprint and/or resistance training. These data are in agreement with similar studies that have observed no effect of resistance training on FBG in healthy older adults (Ferrara et al., 2004; Zachwieja et al., 1996). In the present study, 12 weeks of ETC nonsignificantly reduced FBG by 12.6% but was accompanied by a large ES (-0.83) in the ETC group. Previous research examining the effect of sprint and endurance training in masters athletes suggest that long-term sprint training may not have a favourable effect on glucose metabolism (Kusy and Zieliński, 2015; Kusy et al., 2013). Importantly, the FBG of both the RTC and ETC groups were within the acceptable range for FBG (World Health Organization, 2006) suggesting that RTC and ETC training maintains FBG within healthy ranges. Taken together, the results of the current study suggest that 12 weeks of RTC or ETC does not negatively affect FBG in masters endurance cyclists who replace part of their normal endurance training with sprint-only or concurrent sprint and resistance training.

Elevated TC increases the risk for cardiometabolic disease, particularly with age (Campesi et al., 2016). The present study is the

first to examine the effect of ETC and RTC on TC in masters athletes. We observed that 12 weeks of ETC or RTC did not negatively affect TC levels in masters endurance cyclists who lowered their endurance training volume to accommodate the ETC or RTC training. These findings are consistent with previous studies examining the effect of sprint cycling training on blood lipids in overweight and previously sedentary middle-aged men (Moreira et al., 2008; Wallman et al., 2009). Previous research has also shown that masters athletes (45.9 ± 4.8 years) who regularly participate in field sports such as soccer or hockey had significantly lower TC levels than age-matched sedentary controls (Dey et al., 2002). These data suggest that sports which involve repeated powerful muscular actions and sprinting may exert a positive effect on TC in masters athletes. The findings of the present study support this suggestion with a small effect (-0.10) and 10.6% reduction in TC following 12 weeks of track sprint cycling training. Taken together, this data suggests reducing replacing a portion of endurance training with track-sprint training does not negatively affect T-C in masters endurance cyclists.

In the present study, TC was reduced by 7.1% within the RTC group, but these changes were not significant. However, the reductions in TC observed in the present study may be clinically relevant since as little as a one percent reduction in TC has been shown to be associated with a two to three percentage reduction in the incidence of coronary heart disease (Law et al., 1994). Therefore, our data suggests both ETC and RTC training may be used by older populations to lower TC and impact on cardiometabolic health. To date, no research has investigated the effects of resistance training on TC in masters athletes. The present findings are in agreement with previous research which has shown in untrained older men, high intensity resistance training favourably effects TC levels (Hagerman et al., 2000; Joseph et al., 1999; Leenders et al., 2013). In addition, previous research (Martins et al., 2010) has reported moderate to high intensity resistance training also induces favourable changes in TC in healthy older males (76 ± 8.0 years). Taken together, these results again suggest TC is not negatively influenced by RTC training in masters endurance cyclists.

Elevated TG are an independent risk factor for cardiometabolic disease (Pirillo et al., 2014). In the current study, 12 weeks of either ETC training or RTC training had no significant effect on TG in masters endurance cyclists. These results are in agreement with previous studies that have reported no significant reduction in TG in response to high intensity sprint training in overweight, middle-aged males and females (Moreira et al., 2008) and obese middle-aged males and females (Wallman et al., 2009). Moreover,

previous studies have also reported no significant reduction of resistance training alone on TG in healthy older men (Hagerman et al., 2000) and overweight older males and females (Joseph et al., 1999).

In summary, the lack of a significant affect of ETC and RTC on TC and TG in the current study may be attributed to the following factors. First, participants in both the training groups were already well-trained endurance cyclists and thus may have already lowered their lipids, a finding commonly observed following years of endurance training (Thompson et al., 1988; Wallman et al., 2009). Secondly, the small detraining effect on VO_{2peak} observed in the RTC and ETC groups may be partly responsible for the small changes in TC and TG. For example, Giada et al. (1995) reported an 8-week detraining period significantly increased TG and decreased high-density lipoprotein cholesterol in conjunction with a significant decrease in VO_{2peak} in a group of masters cyclists aged 50–65 years.

Hypertension is associated with several cardiometabolic disorders including diabetes and dyslipidaemia (Neves et al., 2013). In the current study, 12 weeks of RTC training reduced SBP by 3.0 mmHg and DBP by 1.0 mmHg with these results accompanied by a moderate effect on SBP (-0.48) but no effect on DBP. To the best of our knowledge, no previous studies have investigated the effects of resistance training on blood pressure in masters athletes. However, previous research suggests moderate intensity resistance training has favourable effects on blood pressure in healthy older adults (Collier et al., 2008; Westcott et al., 2009). While the present changes were not statistically significant, a 5-mmHg drop in SBP at a population level is associated with a 9% reduction in death due to coronary Heart Disease (Sharman and Stowasser, 2009). Thus, the current study demonstrates that RTC training may have the potential to further reduce BP and thus cardiometabolic risk in masters endurance cyclists.

The current study observed no negative effect of ETC training on SBP or DBP in masters endurance cyclists. In the present study, 12 weeks of ETC training reduced SBP by 8 mmHg and DBP by 2.2 mmHg nonsignificantly with but with these reductions complemented by a large effect on SBP (-0.87) and a moderate effect on DBP (-0.65). However, the observed nonsignificant reductions in SBP observed in the present study may be clinically relevant since a reduction in SBP of 3 mmHg for normotensive individuals such as those in the present study has been shown to reduce all-cause mortality by 4% at a population level (Collier et al., 2008).

Previous observational studies have suggested that sprint train-

ing may reduce BP measures in aging athletes when comparing blood pressure values in masters track and field athletes with those from healthy, age-matched controls (Hernelahti et al., 2002; Kettunen et al., 2006). Therefore, the present and previous results suggest ETC training may be used in a prehypertensive older population to lower BP. In summary, the results of the current study suggest replacing a portion of endurance training with either ETC alone or RTC training does not have a negative effect on both SBP and DBP in masters endurance cyclists.

Finally, in the present study, we observed a small but nonsignificant decrease in VO_{2peak} in the RTC group (-2.3%) and the ETC group (-3.9%). In contrast the CTRL group demonstrated a small nonsignificant increase (1%). However, these changes are within standard error of measurement ranges for VO_{2peak} testing both within our laboratory and Australian accredited exercise testing laboratories (Tanner and Gore, 2013). These results suggest that replacing a portion of endurance training with 12 weeks of either ETC or RTC training does not significantly reduce VO_{2peak} , despite a reduction in overall endurance training volume.

The results of the present study suggest that 12 weeks of ETC or RTC training favourably affects body composition by lowering TFM and increasing LLM in well-trained masters endurance cyclists. These positive changes in body composition may lower the risk for cardiometabolic disease. Moreover, the present findings suggest that cardiometabolic health indicators including FBG, TC, TG, SBP, and DBP are unaffected by a reduction in endurance training volume in masters endurance cyclists who replace part of their endurance training volume and undertake resistance and/or sprint training.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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