Effects of Concentric and Eccentric Cycling Exercise Training on Phenotype and Mitochondrial Functions in Lymphocytes

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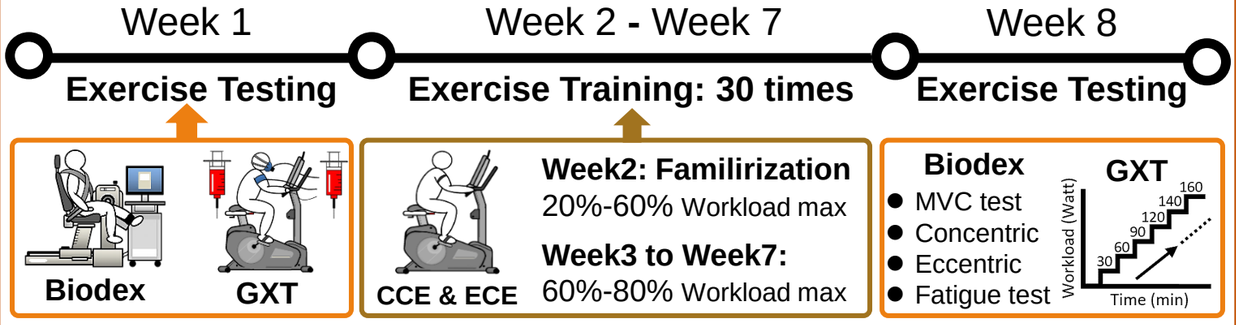
Background and Purpose

Eccentric cycling exercise features several beneficial effects like higher force output, lower metabolic demand and perceived exertion, and it can be applicable even for elderly and individuals with exercise intolerance. Lymphocytes play an essential role in adaptive immunity, and phenotype of lymphocytes represent different states during eccentric cycling exercise. Metabolic pathways along with bioenergetic health index (BHI) in mitochondria dominate the quality of immune function in lymphocytes. The purpose of this study was to investigate the effects of chronic concentric and eccentric cycling exercise training regimen on phenotypic characteristics and mitochondrial functions like respiratory capacity, membrane potential, oxidative stress and content in lymphocytes in healthy male participants.

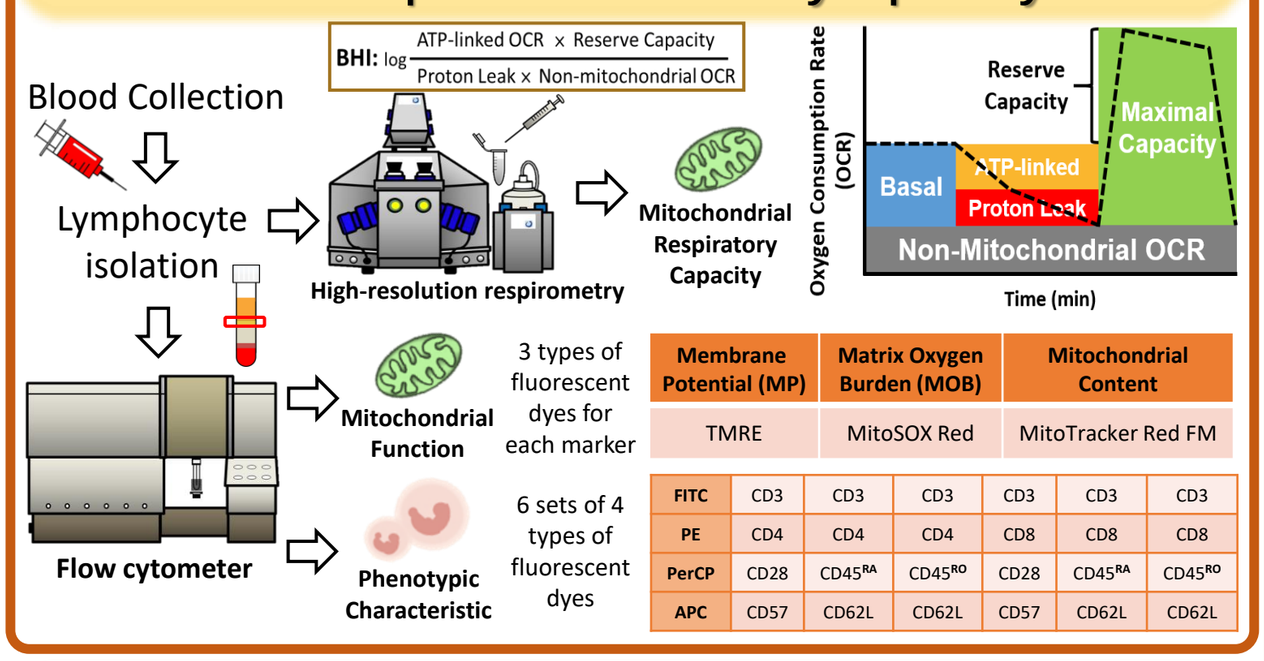
Material and Methods

22 healthy young men with inactive lifestyle were randomly assigned to engage in either concentric cycling exercise training (CCE, n=11) or eccentric cycling exercise training (ECE, n=11) for 30 min/day, 5 days/week for 6 weeks. All subjects performed a graded exercise test (GXT) on a bicycle ergometer and isokinetic strength tests with a dynamometer (Biodex) to assess their aerobic exercise performance and maximal strength of their knee extensors, respectively. Blood samples were collected before and after a GXT to isolate lymphocytes for measuring mitochondrial content, membrane potential (MP), matrix oxidant burden (MOB) and phenotypic characteristics in T cell specifically with four color flow cytometer. Besides, mitochondrial respiratory capacity, and BHI were determined using a high-resolution respirometry.

Experimental Protocol for 8 weeks



Blood Experiments for Lymphocyte



Membrane Potential (MP)	Matrix Oxygen Burden (MOB)	Mitochondrial Content
TMRE	MitoSOX Red	MitoTracker Red FM

FITC	CD3	CD3	CD3	CD3	CD3	CD3
PE	CD4	CD4	CD4	CD8	CD8	CD8
PerCP	CD28	$CD45^{RA}$	$CD45^{RO}$	CD28	$CD45^{RA}$	$CD45^{RO}$
APC	CD57	CD62L	CD62L	CD57	CD62L	CD62L

Conclusion

After training for 6 weeks, improved exercise performance (GXT and muscle strength) were observed in both CCE and ECE. Compared with CCE, ECE can retain more mitochondrial reserve capacity in intact lymphocytes. It can be indicated that ECE possesses better protective mechanisms for mitochondria in lymphocytes and lower perceived exertion even during high-intensity aerobic exercise.

Results

▼ Exercise Performance: GXT, HR, and VAS

	CCE (N=11)		ECE (N=11)	
	Pre	Post	Pre	Post
Anthropometric Data				
Age (year)	21.1 ± 0.5	21.2 ± 0.6	21.7 ± 0.6	21.8 ± 0.6
Height (cm)	173 ± 1.2	173 ± 1.2	172 ± 1.7	172 ± 1.7
Weight (kg)	68.7 ± 2.2	68.1 ± 2.1	70 ± 2.9	69.6 ± 3.1
BMI (kg/m^2)	22.9 ± 0.8	22.7 ± 0.7	23.6± 0.9	23.5 ± 0.9
Ventilation Threshold				
Work Rate (watt)	108 ± 9.0	144 ± 6.5 *+	103 ± 6.9	115 ± 8.0*
Exercise Time (min)	11.4 ± 1.1	16.2 ± 1.1*+	11.4 ± 0.8	11.8 ± 0.8
HR(beats/min)	128 ± 6.6	143 ± 5.0*+	133 ± 4.8	134 ± 4.3
VE (l/min)	40.2 ± 3.2	50.5 ± 2.4*+	36.4 ± 1.8	38.6 ± 2.3
VO_2 (ml/min/kg)	20.0 ± 1.6	25.6 ± 1.3*+	19.4 ± 1.3	19.6 ± 1.3
VCO_2 (ml/min/kg)	20.4 ± 1.6	26.1 ± 1.3*+	19.7 ± 1.3	20.1 ± 1.3
Maximal Exercise Performance				
Work Rate (watt)	171 ± 6.3	215 ± 7.2*+	176 ± 7.0	191 ± 6.3*
Exercise Time (min)	21.2 ± 0.9	27.5 ± 1.1*+	21.7 ± 1.2	23.1 ± 1.1*
HR (beats/min)	182 ± 3.1	184 ± 2.6	187 ± 2.9	190 ± 1.9
VE (l/min)	89.3 ± 5.0	108.2 ± 5.1*	91.8 ± 5.3	104.2 ± 4.7*
VO_2 (ml/min/kg)	31.8 ± 1.4	37.0 ± 1.6*+	31.1 ± 2.0	32.0 ± 1.6
VCO_2 (ml/min/kg)	37.0 ± 1.6	43.0 ± 1.8*+	37.8 ± 2.3	38.9 ± 2.0

Table1. Exercise training effects on GXT exercise performance. Values were mean ± SE. CCE, Concentric cycling exercise group; ECE, Eccentric cycling exercise group; Pre, pre-intervention; Post, post-intervention; BMI, body mass index; VE, minute ventilation; VO_2, oxygen consumption; VCO_2, carbon dioxide production. *P < 0.05, Pre vs. Post; +P < 0.05, CCE vs. ECE.

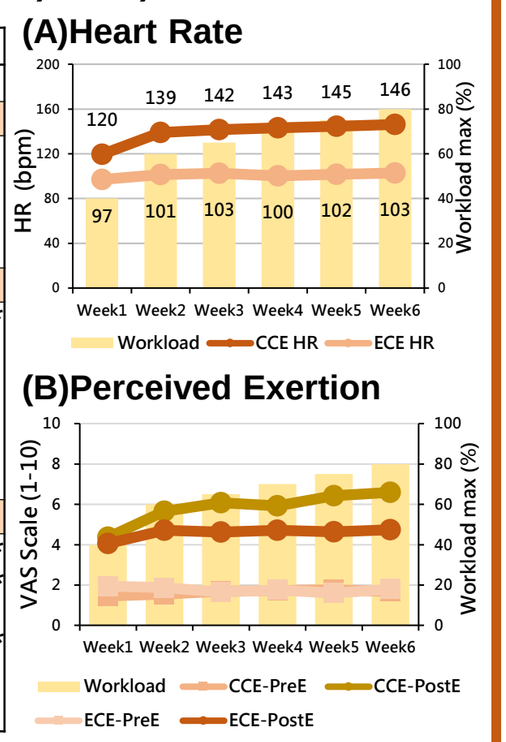


Figure1. Average of (A) heart rate and (B) perceived exertion of each week. Values were mean ± SE. CCE, Concentric cycling exercise group; ECE, Eccentric cycling exercise group; PreE, before exercise; PostE, after exercise.

▼ Exercise Performance: Isokinetic Strength Test

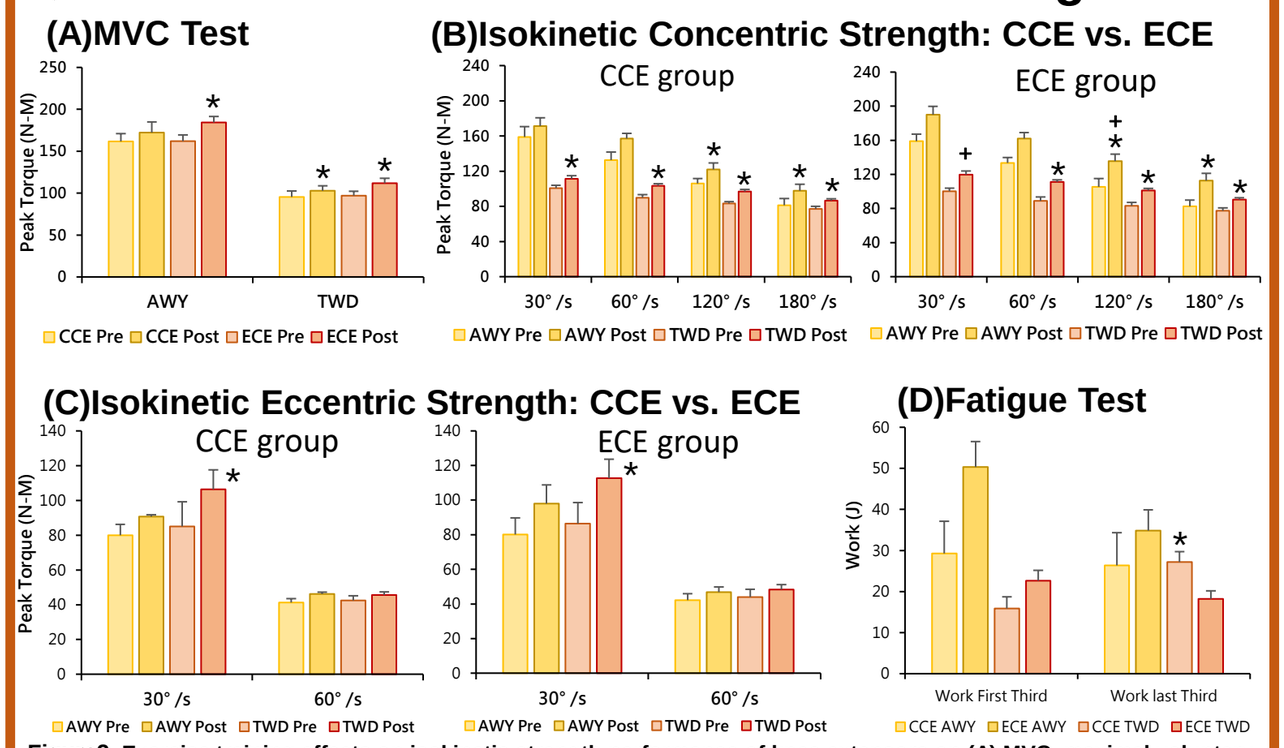


Figure2. Exercise training effects on isokinetic strength performance of knee extensors on (A) MVC, maximal voluntary contraction, (B) Isokinetic concentric strength test, (C)Isokinetic eccentric strength test, and (D)Fatigue test. Values were mean ± SE. AWY, away (knee extension); TWD, toward (knee flexion); CCE, Concentric cycling exercise group; ECE, Eccentric cycling exercise group; Pre, pre-intervention; Post, post-intervention. *P < 0.05, Pre vs. Post; +P < 0.05, CCE vs. ECE.

▼ Mitochondrial Function in Intact Lymphocytes

Figure2. Exercise training effects on mitochondrial O_2 consumption rate (OCR) in the intact lymphocytes. Values were mean ± SE. ATP, ATP-linked OCR; Uncouple, uncouple OCR; Maximum, Maximal capacity; Reserve, the reserve capacity of OCR; Non-mito, Non-mitochondrial OCR; CCE, Concentric cycling exercise group; ECE, Eccentric cycling exercise group; Pre, pre-intervention; Post, post-intervention. *P < 0.05, Pre vs. Post; +P < 0.05, CCE vs. ECE.

▼ Mitochondrial Function: Fluorescence Expression

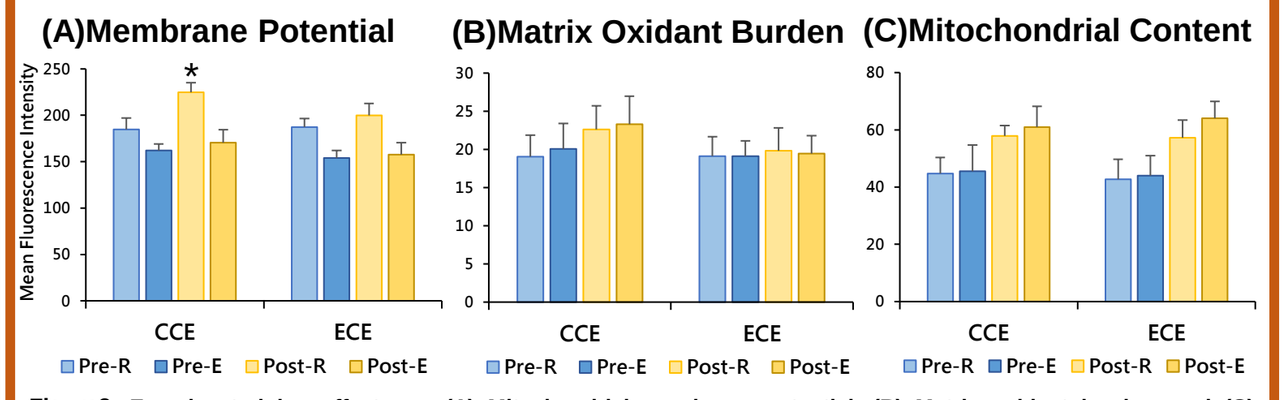


Figure2. Exercise training effects on (A) Mitochondrial membrane potential, (B) Matrix oxidant burden, and (C) Mitochondrial content in lymphocytes. Values were mean ± SE. CCE, Concentric cycling exercise group; ECE, Eccentric cycling exercise group; Pre, pre-intervention; Post, post-intervention. *P < 0.05, Pre vs. Post.