HEART RATE VARIABILITY OF OLDER WORKERS DURING WORK UNDER HEAT: ARE THEY ADEQUATELY PROTECTED?

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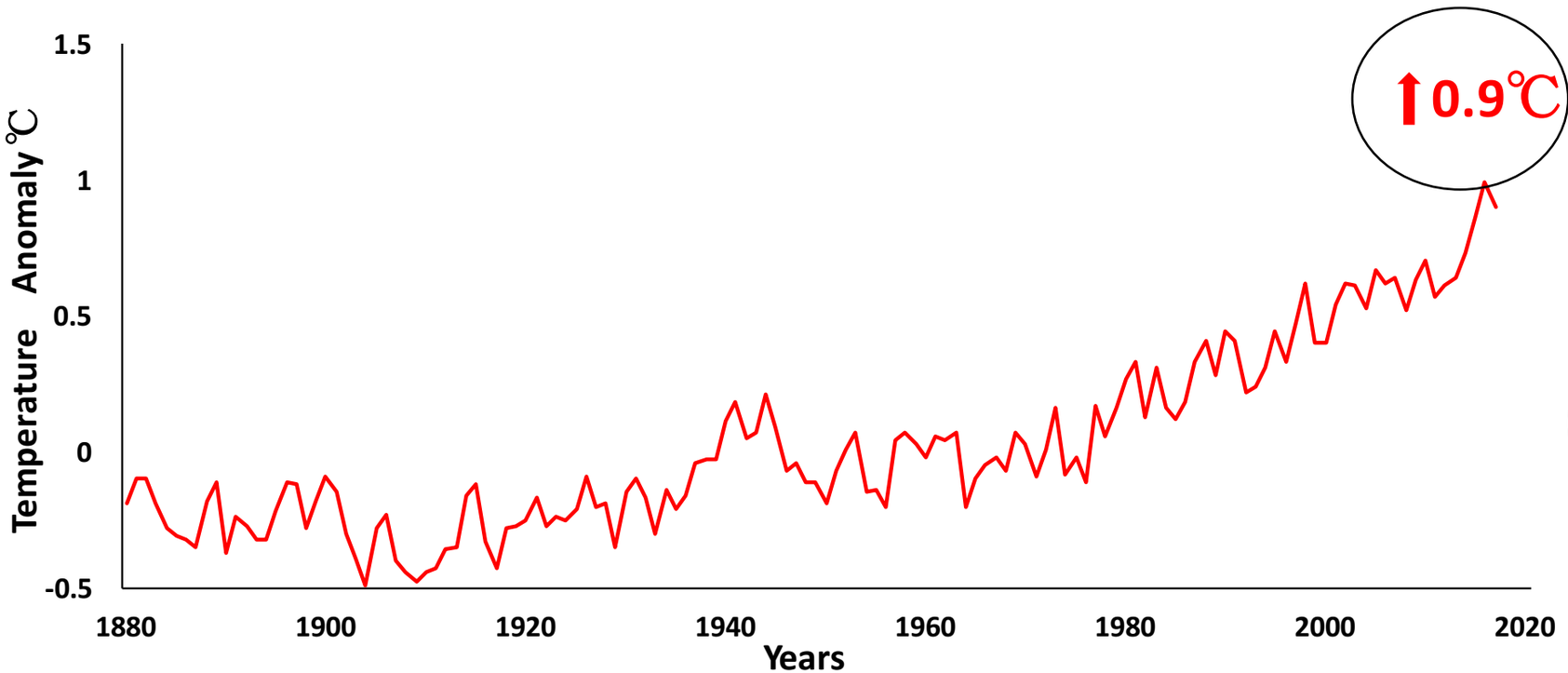
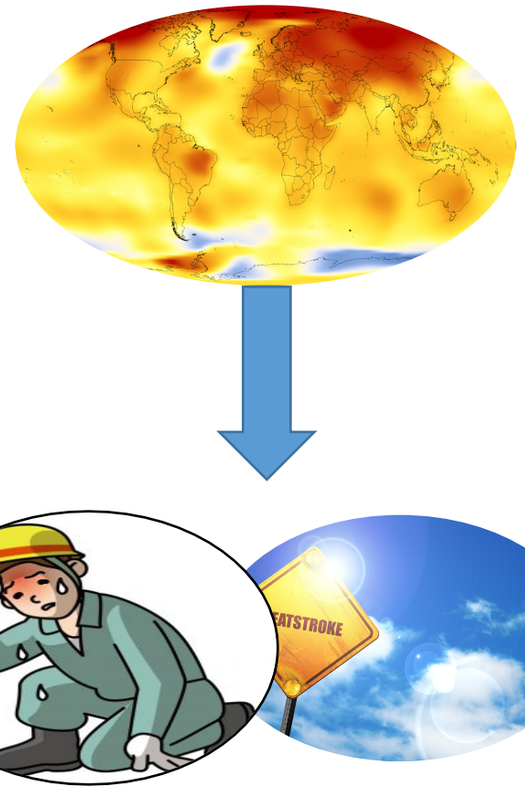
CLIMATE CHANGE: A THREAT TO HUMAN HEALTH

Change in global surface temperature





Heat-related illness & death

OLDER ARE AT INCREASED RISK OF HEAT-RELATED ILLNESS

Reduced ability to increase sweat perfusion & sweat production

⬇

Impaired ability to dissipate heat

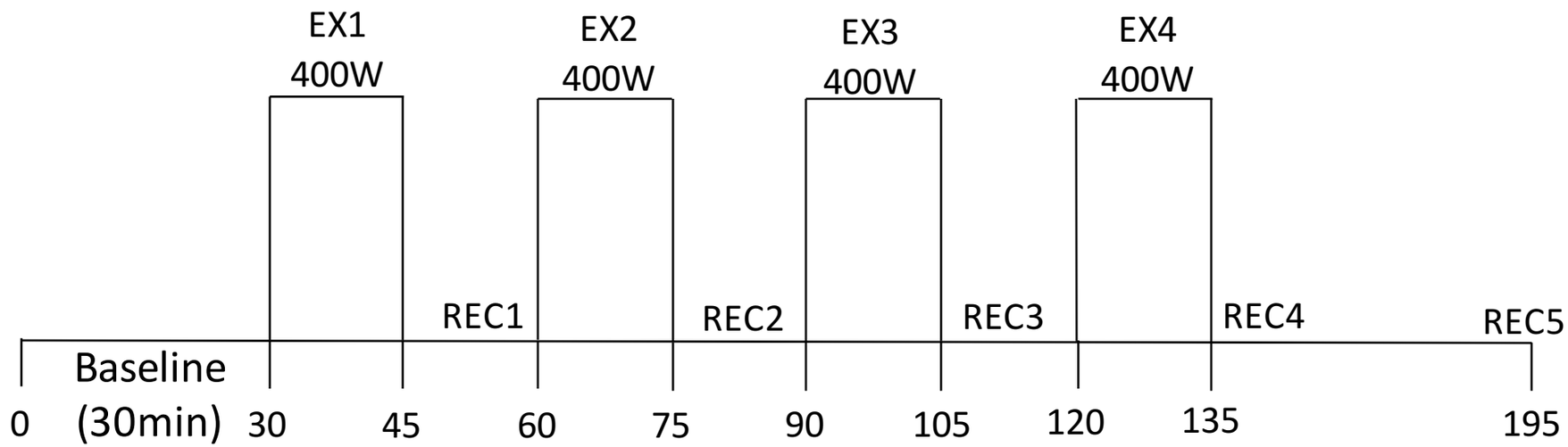
⬇

Increased risk for heat-related illness & death

AGE DIFFERENCES IN CARDIAC AUTONOMIC MODULATIONS DURING INTERMITTENT EXERCISE IN THE HEAT

33 males
YOUNG 25.8±1.9
MIDDLE AGED 43.5±2.8
OLDER 62.9±3.7

Total Duration = 195 min or ~2 hours
35°C and 20% relative humidity



Exercise
(15 min each; total 60 min)
Bseline rest & Recovery
(30 min rest; 15 min each; final recovery 60min; total 120 min)

Under review by the Br J Sports Med

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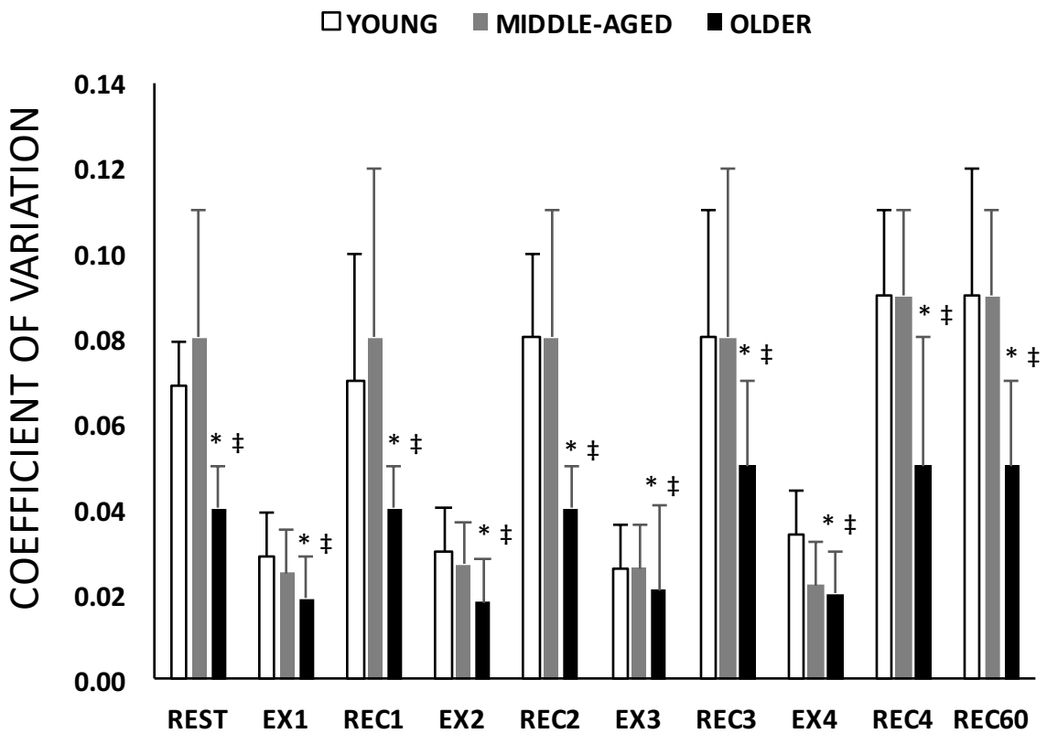
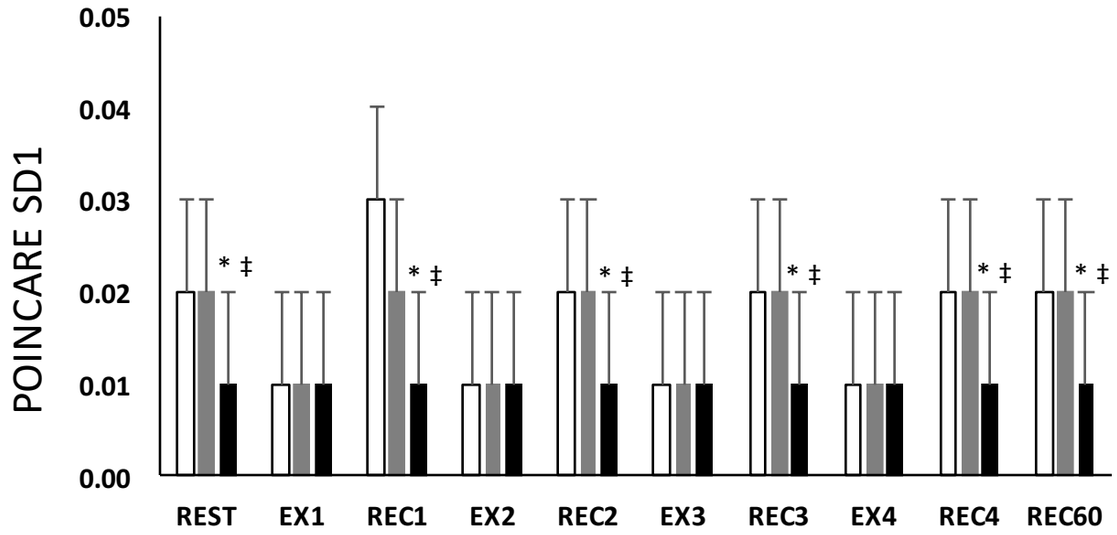
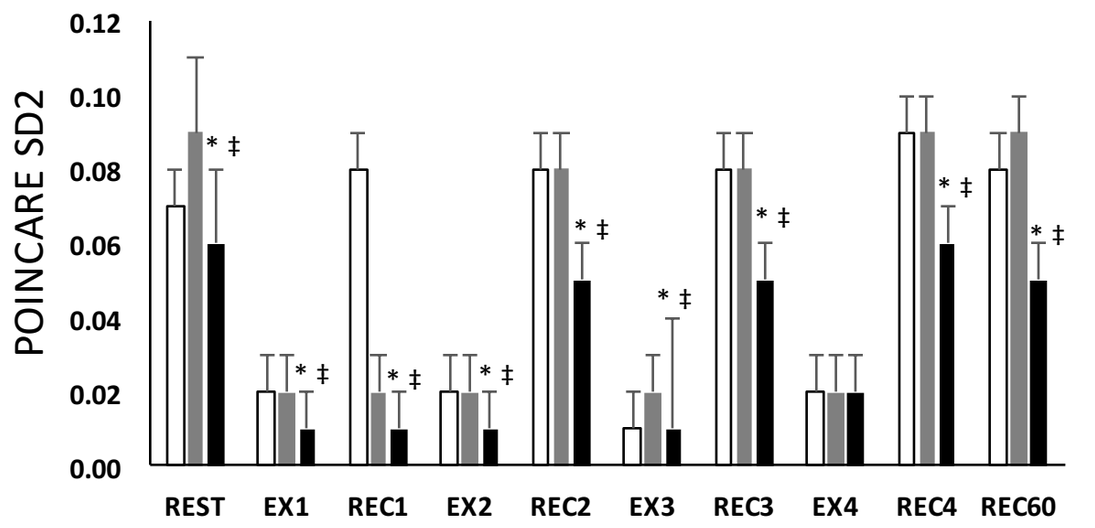
RESULTS







Note: * = statistically significant ($p<0.05$) differences between YOUNG and OLDER
‡ = statistically significant ($p<0.05$) differences between MIDDLE-AGED and OLDER

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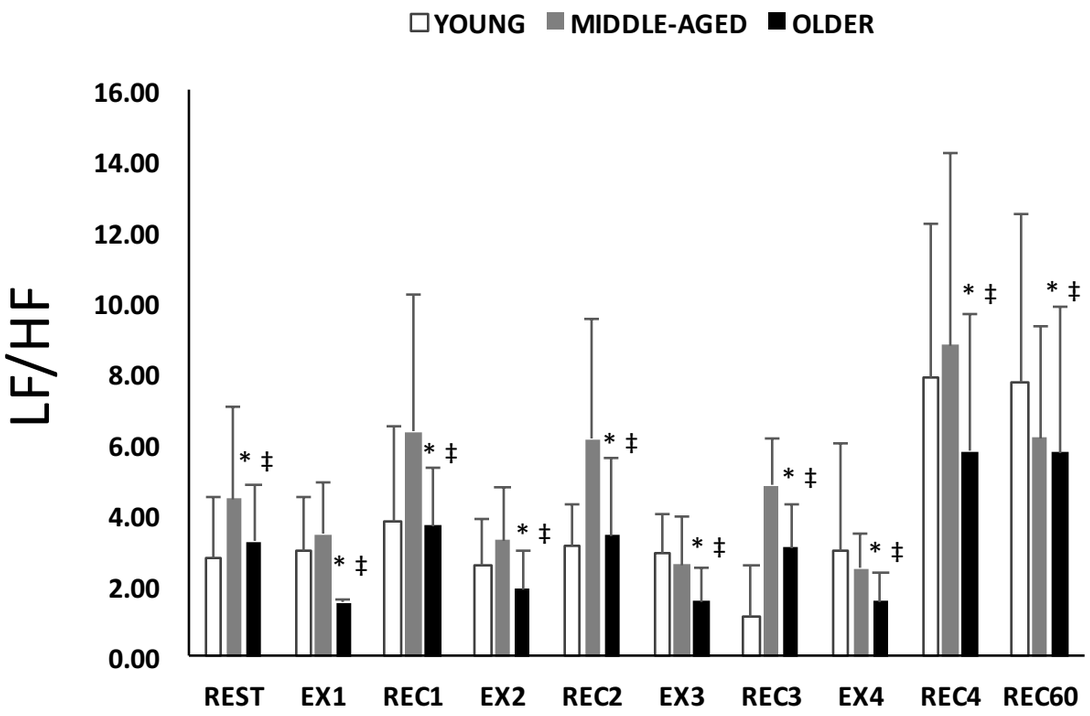
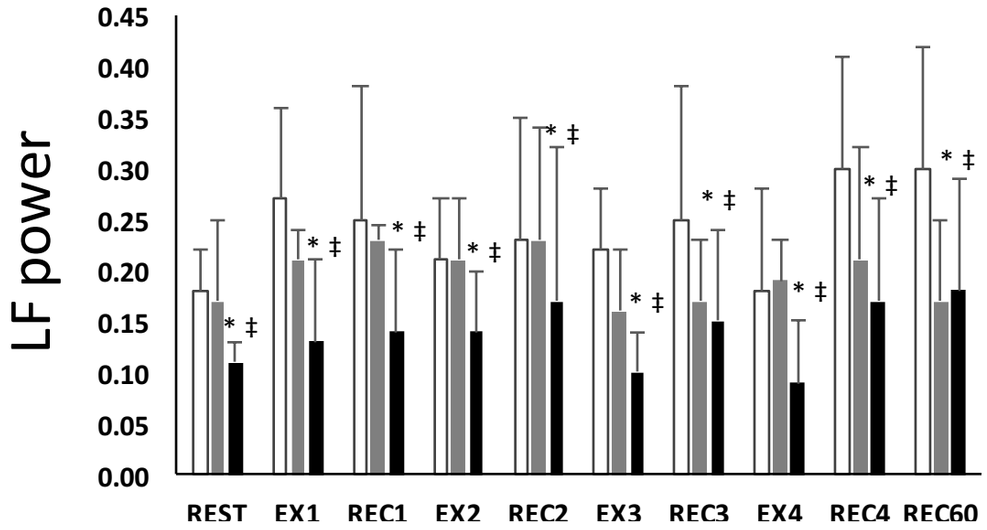
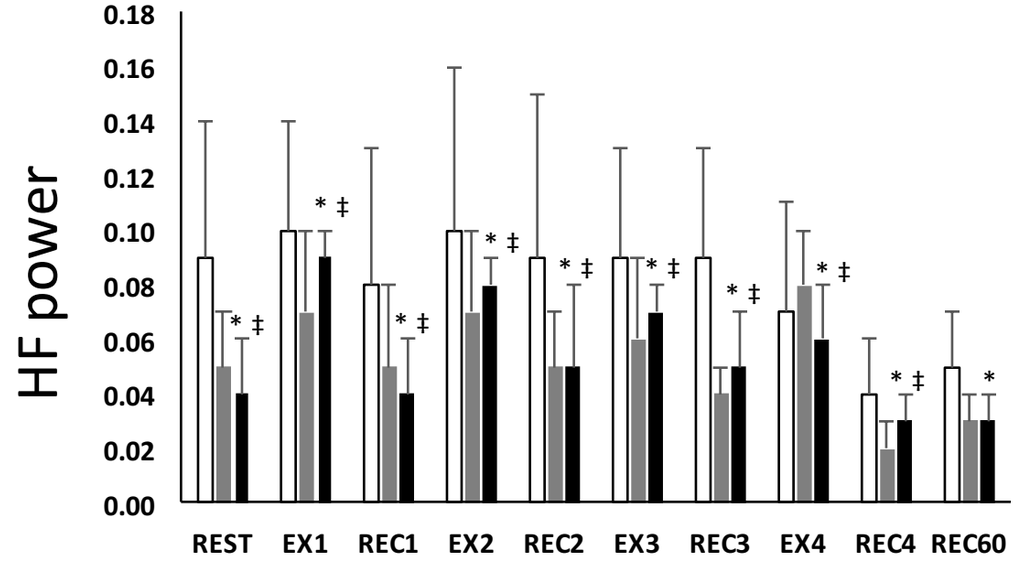
RESULTS





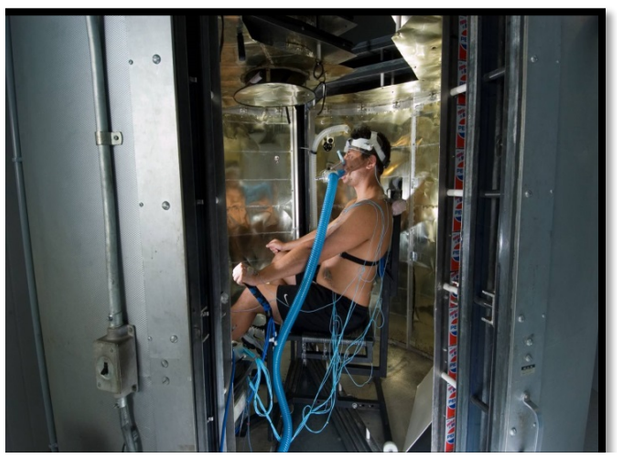


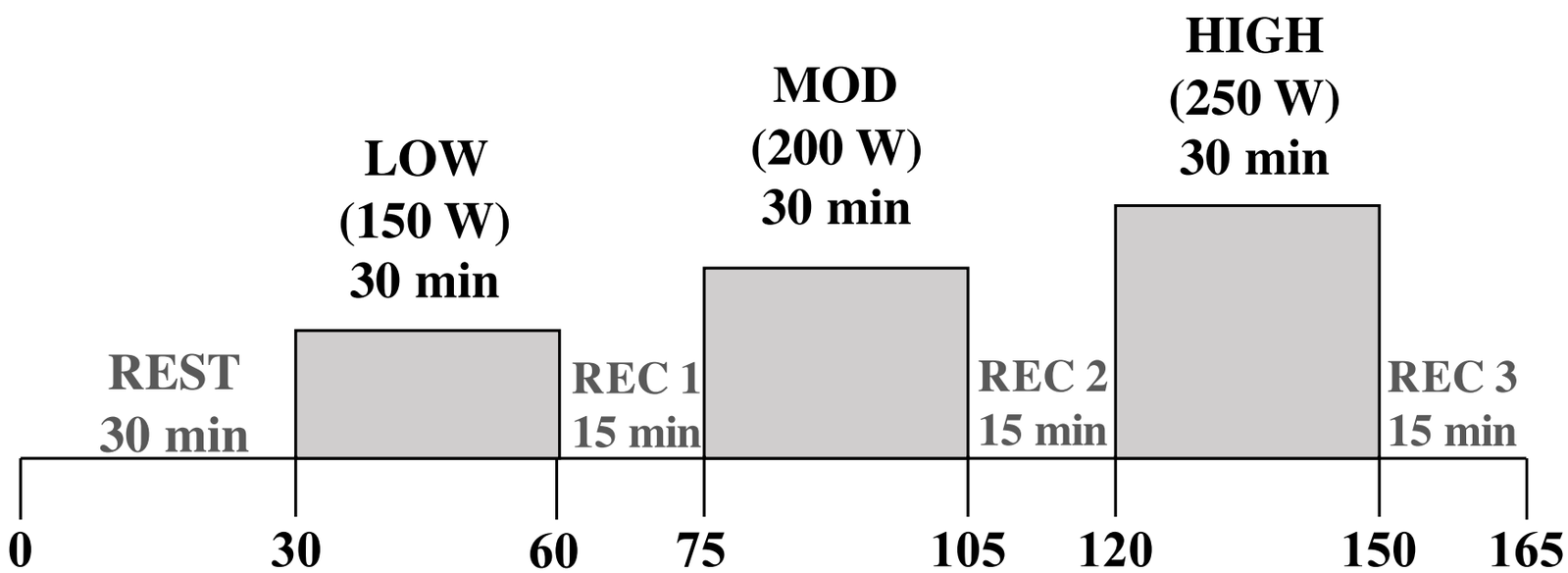
Note: * = statistically significant ($p<0.05$) differences between YOUNG and OLDER
‡ = statistically significant ($p<0.05$) differences between MIDDLE-AGED and OLDER

TYPE 2 DIABETES IMPAIRS CARDIAC AUTONOMIC ACTIVITY

12 men with well-controlled Type 2 Diabetes patients: 59.09±6.01 years
12 healthy controls: 60.55±3.39 years

Ambient temperature of 40˚C and a relative humidity of ~20%





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RESULTS

Heart rate variability indices during the last 5 min of each exercise period

	T2D patients			Healthy controls		
	LOW	**MOD**	**HIGH**	**EX1**	**EX2**	**EX3**
LF/HF ratio	2.55±1.38	3.29±1.96	2.87±1.75	1.89±1.0	2.31±1.27	3.38±1.67 [b]
LF Power (msec)	0.14±0.04	0.14±0.08	0.08±0.07 [b]	0.132±0.03	0.133±0.05	0.151±0.07
HF Power (msec)	0.079±0.06	0.06±0.05	0.044±0.05 [b c]	0.09±0.05	0.072±0.03	0.05±0.018
Coefficient of variation (%)	0.046±0.02	0.040±0.03	0.052±0.03	0.05±0.02	0.05±0.03	0.05±0.03
Poincaré SD1 (s)	0.013±0.01	0.010±0.01	0.010±0.01	0.021±0.01	0.022±0.002	0.013±0.05
Poincaré SD2 (s)	0.044±0.02	0.040±0.03	0.043±0.03	0.056±0.03	0.051±0.03	0.046±0.03
Largest Lyapunov exponent	0.045±0.02	0.039±0.01	0.05±0.02	0.051±0.02	0.058±0.025	0.048±0.021
Shannon entropy (bits)	4.43±0.7	3.97±0.9	4.15±0.86	4.72±0.71	4.58±0.75	4.42±0.653[b]
DFA Alpha 1 (AUC)	1.15±0.22	0.96±0.37	0.91±0.41	1.15±0.19	1.08±0.266	1.17±0.362
DFA Alpha 2 (AUC)	1.03±0.13	1.08±0.13	1.13±0.26	1.05±0.15	1.02±0.147	0.97±0.139
Hjorth's Complexity	74.6±29.4	86.6±33.7	77.5±29.3	59.3±24.7	64.8±29.6	67.0±30.4

Data are presented as mean ± standard deviation.

Note: [a] = LOW vs MOD; [b] = LOW vs HIGH; [c] = MOD vs HIGH

Key: LOW:low; MOD: moderate; HIGH: high; DFA: Detrended Fluctuation Analysis

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RESULTS

Heart rate variability indices at rest and during the last 5 min of each recovery phase

	T2D patients				Healthy controls			
	REST	**REC1**	**REC2**	**REC3**	**REST**	**REC1**	**REC2**	**REC3**
LF/HF ratio	2.74±1.43	1.81±1.43	1.96±2.05	0.89±0.45[f]	2.83±2.14	2.81±3.18	3.48±4.82	1.41±1.59
LF Power (msec)	0.15±0.06	0.13±0.09	0.09±0.08[e]	0.05±0.02[f]	0.16±0.07	0.13±0.08	0.11±0.06	0.064±0.03[f]
HF Power (msec)	0.68±0.04	0.09±0.08	0.06±0.04	0.06±0.02	0.07±0.03	0.083±0.06	0.07±0.05	0.067±0.04
Coefficient of variation (%)	0.047±0.02	0.033±0.02	0.024±0.01[e]	0.026±0.02	0.057±0.029	0.036±0.022	0.027±0.014	0.046±0.06
Poincaré SD1 (s)	0.014±0.01	0.011±0.01	0.008±0.01[e]	0.008±0.01[f]	0.026±0.02	0.013±0.005	0.009±0.002	0.01±0.006
Poincaré SD2 (s)	0.05±0.02	0.02±0.02[a]	0.015±0.01[e]	0.014±0.01[f]	0.07±0.04	0.030±0.02	0.020±0.012[e]	0.033±0.05
Largest Lyapunov exponent	0.05±0.02	0.05±0.02	0.049±0.01	0.052±0.03	0.05±0.02	0.05±0.03	0.07±0.03	0.04±0.01[d]
Shannon entropy (bits)	4.57±0.53	3.65±0.48[a]	3.16±0.54[e]	2.83±0.70[f]	5.02±0.5	4.01±0.58[a]	3.39±0.44[b e]	3.37±0.86[f]
DFA Alpha 1 (AUC)	1.22±0.17	0.77±0.28[a]	0.59±0.31[e]	0.44±0.27[f]	1.13±0.16	0.92±0.33	0.90±0.46	0.67±0.32[c f]
DFA Alpha 2 (AUC)	1.00±0.18	1.02±0.21	1.18±0.12[e]	1.23±0.27[f]	0.92±0.25	0.93±0.27	1.13±0.18	1.21±0.13[c f]
Complexity	70.1±24.6	77.2±24.9	88.2±23.6	88.3±31.7	49.5±22.1	72.2±25.6	87.6±22.7[e]	90.4±42.7

Data are presented as mean ± standard deviation.

Note: [a] = Rest vs REC1; [b] = REC1 vs REC2; [c] = REC1 vs REC3, [d] = REC2 vs REC3, [e] = Rest vs REC2, [f] = Rest vs REC3

Key: REC: recovery; DFA: Detrended Fluctuation Analysis;

THRESHOLD LIMIT VALUES (TLVs)

The TLV® guidelines may not adequately protect all individuals during work in hot conditions

Authors	Group age (years)	WBGT (°C)	Body Temperature (°C)
Meade et al. 2016	21 ± 3	≈30 °C	> 38
Lamarche et al. 2017	58 ± 5	≈30 °C	> 38

TLVs in Older Adults

1. Continuous CONTROL

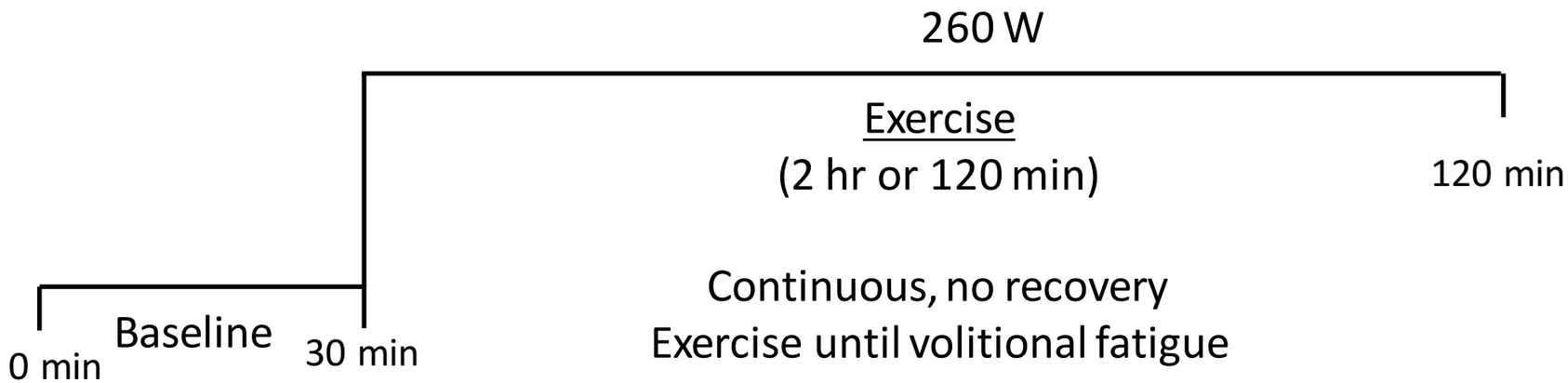
Total Duration = 120 min or 2 hours of continuous cycling

36°C

38% relative humidity

28°C WBGT

9 males 57.7±4.7 years



Unpublished data

TLVs in Older Adults

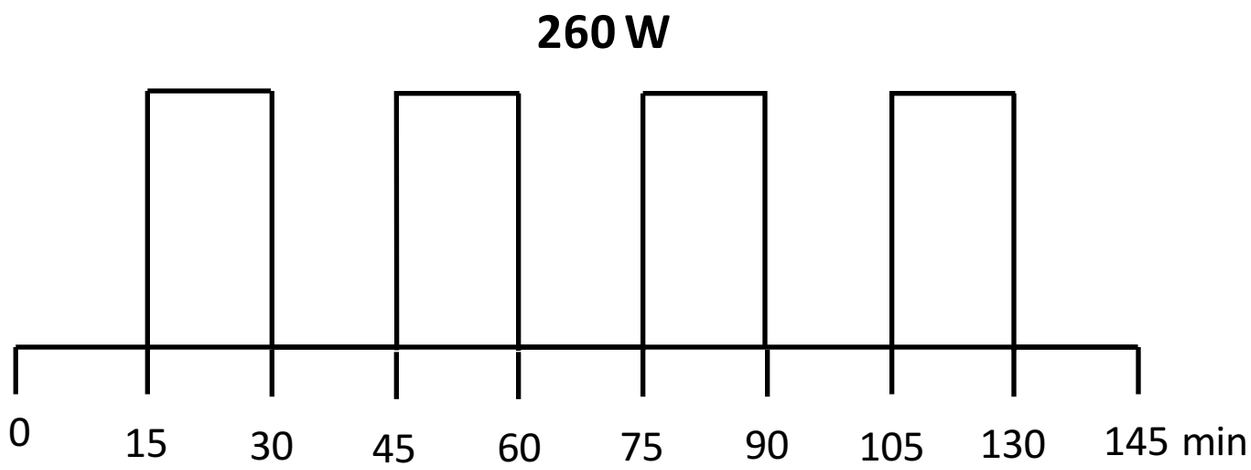
2. Work-to-Rest 1:1

Total Duration = 150 min or 2 hr 30 min

40°C

30% relative humidity

30°C WBGT



Exercise
(15 min each; total 60 min)

Recovery
(15 min each; total 60 min)

TLVs in Older Adults

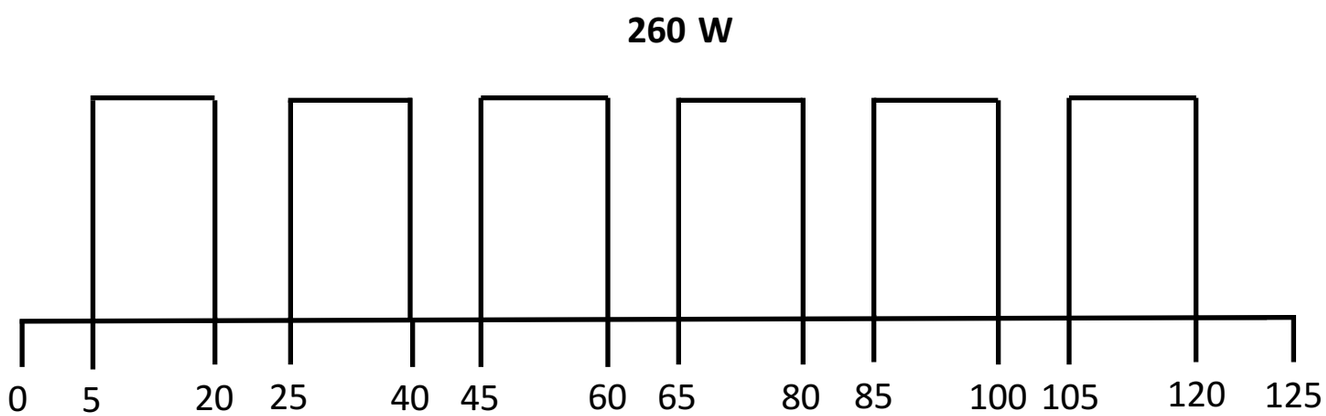
3. Work-to-Rest 3:1

Total Duration = 120 min or 2 hour

38°C

34% relative humidity

29°C WBGT



Exercise
(15 min each; total 90 min)
Recovery
(5 min each; total 30 min)

1ST SCENARIO
Time (baseline, end exercise (60 min)) x Condition (con, 3:1, 1:1)

HRV indices (mean ± sd) at baseline and during the last 5 min of the 1st hour

	CON [28 °C]		**WR1:1 [29 °C]**		**WR1:3 [30°C]**	
	BASELINE	1ST HOUR	**BASELINE**	**1ST HOUR**	**BASELINE**	**1ST HOUR**
Coefficient of variation (%)	0.053±0.02*	0.016±0.040	0.04±0.01	0.07±0.05	0.05±0.02	0.04±0.02
Poincaré SD1 (s)	0.02±0.01*	0.01±0.002	0.01±0.01	0.02±0.02	0.02±0.01*	0.01±0.01
Poincaré SD2 (s)	0.67±0.03*	0.01±0.004	0.04±0.01	0.06±0.06	0.07±0.04*	0.03±0.02
LF/HF ratio	2.77±2.19*	0.90±0.32	1.45±1.43	2.20±1.37	2.50±1.5	2.11±1.10
LF Power (msec)	0.15±0.08*	0.06±0.02	1.65±2.65	0.07±0.021	0.17±0.08*	0.08±0.04
HF Power (msec)	0.69±0.03	0.07±0.03	0.13±0.08	0.06±0.08	0.08±0.03	0.05±0.03
DFA Alpha 1 (AUC)	1.20±0.22*	0.51±0.13	1.20±0.20*	0.87±0.40	1.21±0.12*	0.87±0.30
DFA Alpha 2 (AUC)	0.98±0.18*	1.20±0.11	0.98±0.16*	1.33±0.30	0.93±0.16 *	1.30±0.34
Largest Lyapunov exponent	0.05±0.02	0.05±0.02	0.05±0.02	0.05±0.02	0.05±0.02	0.04±0.02
VLF Power	0.28±0.10*	0.40±0.12	0.33±0.09*	0.50±1.60	0.23±0.07 *	0.47±0.12
Complexity	55.61±26*	111.29±33.8	70.40±16.0	78.4±37.0	52.0±21.4*	95.14±37.31
Shannon Entropy (bits)	5.02±0.58*	2.70±0.52	4.48±0.44	4.20±1.00	4.93±0.64*	3.65±0.63

* $p<0.05$, Rest vs 1st Hour

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2ND SCENARIO
Time (baseline and end exercise (120 min)) x Condition (con, 3:1, 1:1)

HRV indices (mean ± sd) at baseline and during the last 5 min of the 2nd hour

	CON [28 °C]		**WR1:1 [29 °C]**		**WR1:3 [30°C]**	
	BASELINE	**2ND HOUR**	**BASELINE**	**2ND HOUR**	**BASELINE**	**2ND HOUR**
Coefficient of variation (%)	0.053±0.02*	0.016±0.040	0.04±0.01	0.05±0.03	0.05±0.02	0.05±0.04
Poincaré SD1 (s)	0.02±0.01*	0.01±0.002	0.01±0.01	0.015±0.01	0.02±0.01*	0.01±0.01
Poincaré SD2 (s)	0.67±0.03*	0.01±0.004	0.04±0.01	0.04±0.02	0.07±0.04	0.04±0.04
LF/HF ratio	2.77±2.19*	0.95±0.56	1.45±1.43	3.30±1.94	2.50±1.5	1.27±0.59
LF Power (msec)	0.15±0.08*	0.07±0.02	1.65±2.65	0.15±0.01	0.17±0.08*	0.10±0.07
HF Power (msec)	0.69±0.03	0.08±0.04	0.13±0.08	0.08±0.12	0.08±0.03	0.08±0.05
DFA Alpha 1 (AUC)	1.20±0.22*	0.50±0.17	1.20±0.20	1.21±0.42	1.21±0.12*	0.75±0.33
DFA Alpha 2 (AUC)	0.98±0.18*	1.20±0.14	0.98±0.16	1.03±0.23	0.93±0.16 *	1.23±0.21
Largest Lyapunov exponent	0.05±0.02	0.07±0.04	0.05±0.02	0.06±0.03	0.05±0.02	0.04±0.02
VLF Power	0.28±0.10	0.34±0.13	0.33±0.09	0.36±0.20	0.23±0.07*	0.47±0.18
Complexity	55.61±26*	108.8±36.9	70.40±16.0	82.7±44.8	52.0±21.4	76.82±42.63
Shannon Entropy (bits)	5.02±0.58*	2.56±0.56	4.48±0.44	4.16±0.81	4.93±0.64*	3.56±1.19

* $p<0.05$, Rest vs 1st Hour

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SUMMARY

- Older men are not being adequately protected when performing intermittent physical activity or physical work in the heat
- The need for reducing the physical work effort (e.g., reducing the work intensity, limiting the number of working hours or increasing the number of breaks) in older individuals emerges
- These results provide insights for the development of preventative health strategies for heat-related illness and mortality in vulnerable individuals