

GEORGIA TORRES

PhD (CSCS)

Effect of exercise intervention programmes on anthropometric, physiological and cardio-metabolic parameters of persons with and without metabolic syndrome.

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THE STUDY

Effect of exercise intervention programmes on anthropometric, physiological and cardio-metabolic parameters of persons with and without metabolic syndrome.

Study **compared the effects** on the **components of the MetS** of an **exercise programme** that uses **blood lactate transition thresholds** (anaerobic threshold (AT)) to the **same measurements** obtained in an exercise **programme** (not using AT) appearing in the literature.

The **main aim** of the study was to design an **exercise programme** that **optimised exercise responses** and **may** thus **improve metabolic characteristics** in individuals with MetS.



THE STUDY

The intention of using at?

To individualise the exercise programme and optimise the improvements in metabolic characteristics.



METHODS

Only Males (25 – 55 yrs old) were used in this study

Individuals with CVD, pulmonary disease and
Type 1 diabetes were not included

A

Ten subjects with MetS exercised using the **walking programme** of Leon *et al* (1979) (Group: MetSL).

B

Ten subjects with MetS exercised using **velocity at AT to set training intensities** (Group: MetSV).

C

Ten subjects without MetS exercised using **velocity at AT to set training intensities** (Group: Non-MetSV).



DIAGNOSIS

The presence of any 3 of the 5 criteria denoted below constituted a diagnosis of MetS:

(Alberti, 2009).

1. **Waist circumference** (≥94 cm);
2. **triglycerides** (≥1.7 mmol/L) or **drug treatment** for high triglycerides;
3. **HDL-cholesterol** (<1.0 mmol/L) or **drug treatment** for reduced HDL-cholesterol;
4. **elevated blood pressure** (≥130/85) or on **anti-hypertensive drug treatment;**
5. **elevated fasting glucose** (≥5.6mmol/L) or **drug treatment** for glucose intolerance.



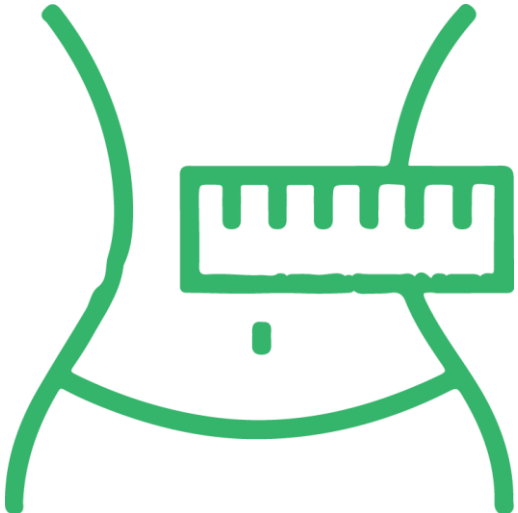
ANTHROPOMETRIC PARAMETERS

HEIGHT

WEIGHT

BMI

Waist circumference (taken as the greatest reading around the girth, midway between lateral lower ribs and the iliac crests).





PHYSIOLOGICAL PARAMETERS

Blood pressure: Sitting position; an average taken of two readings.

Peak VO2 and heart rate were measured using the Cortex, Biophysik, Metalyzer 3b CPX on-line system.

A BLTT test and ECG were performed at the same time.



CARDIO-METABOLIC PARAMETERS

Blood serum concentrations of:

- **Triglycerides;** HDL; LDL and **total cholesterol.**
- An oral **glucose tolerance test** (OGTT): Fasting state; administering a 75 g glucose load.
- Fasting, 30 minute and two-hour **glucose and insulin levels.**
- The HOMA-IR (Matthews *et al*, 1985)



TRAINING PROGRAMMES:

Leon et al (1979): for METSL Group



The training programme for groups using AT to set training intensity

Week	Day	Speed (Kph)	Duration (minutes)	Elevation(% grade)
1	M	2.4	10 + 5 rest + 5	0
1	T	2.4	10 + 5 rest + 5	2
1	W	2.4	10 + 5 rest + 10	2
1	Th	2.4	10 + 5 rest +10 + 5 rest + 5	4
1	F	2.6	10 + 5 rest +10 + 5 rest + 5	4
2	M	2.6	10 + 5 rest +10	2
2	T	2.8	10 + 5 rest +10 + 5rest + 5	2
2	W	3.0	10 + 5 rest +10 + 5 rest +10	4
2	Th	3.2	15 + 5 rest +10 + 5 rest +10	4
2	F	3.4	15 + 5 rest +15 + 5 rest +15	6
3	M	3.4	15 + 5 rest +10 + 5 rest +10	4
3	T	3.6	15 + 5 rest + 15 + 5rest +15	4
3	W	3.8	20 + 5 rest + 15 + 5 rest +15	6
3	Th	4.0	20 + 5 rest + 20 + 5 rest +15	6
3	F	4.2	20 + 5 rest + 20 + 5 rest +20	6.5
4	M	4.2	20 + 5 rest + 20 + 5 rest +15	6
4	T	4.4	20 + 5 rest + 20 + 5 rest +20	6
4	W	4.6	25 + 5 rest + 20 + 5 rest +20	6.5
4	Th	4.8	25 + 5 rest + 25 + 5 rest +20	6.5
4	F	5.0	25 + 5 rest + 25 + 5 rest +25	7
5	M	5.0	25 + 5 rest + 25 + 5 rest +20	6.5
5	T	5.0	25 + 5 rest + 25 + 5 rest +25	6.5
5	W	5.1	30 + 5 rest + 25 + 5 rest +25	7
5	Th	5.1	30 + 5 rest + 30 + 5 rest +25	7
5	F	5.1	30 + 5 rest + 30 + 5 rest +30	7.5
6	M,T,W,Th,F	5.1	30 + 5 rest + 30 + 5 rest +30	7.5
7	M	5.1	30 + 5 rest + 30 + 5 rest +30	7.5
7	T	5.1	30 + 5 rest + 30 + 5 rest +30	8
7	W	5.1	30 + 5 rest + 30 + 5 rest +30	7.5
7	Th	5.1	30 + 5 rest + 30 + 5 rest +30	7.5
7	F	5.1	30 + 5 rest + 30 + 5 rest +30	8
8 - 20	M,T,W,Th,F	5.1	30 + 5 rest + 30 + 5 rest +30	8

TRAINING PROGRAMMES:

For MetSV and non-MetSV groups – using AT



The training programme for groups using AT to set training intensity

Week	Duration (mins/session)	Frequency (sessions/week)	Intensity (% anaerobic threshold)
1	20	3	90
2	25	3	90
3	25	3	95
4	20	3	95
5	25	3	100
6	30	3	100
7	35	4	100
8	25	3	100
9	35	4	100
10	40	4	100
11	45	4	100
12	35	3	100
13	45	4	100
14	50	4	100
15	55	4	100
16	40	3	100
17	55	4	100
18	60	4	100
Week 19			
Day	Duration (mins/session)	Frequency (sessions/week)	Intensity (% anaerobic threshold)
1	40	1	100
2	35	1	100
3	30	1	100
Week 20			
Day	Duration (mins/session)	Frequency (sessions/week)	Intensity (% anaerobic threshold)
1	25	1	100
2	20	1	100
3	15	1	100

HOW TECHNOGYM WELLNESS SYSTEM WORKS…



Assessments and training prescription



Step 1: load key



Step 2: insert key



Step 3: unload results

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MEDICATIONS AND NUTRITIONAL ANALYSIS

- **No** participants used any **confounding medications** (eg. Statins; Glucophage).
- All participants were given a **standardised nutrition programme** in an attempt to get a **similar energy intake** across the 3 groups.
- The **Willett food frequency** questionnaire (Lee, 1996) in combination with a **24 hour eating record** for 3 days were used to monitor the **energy intake.**
- Nutritional records were **analysed for caloric content** using the site *www.nal.usda.gov/fnic/foodcomp/search*.



STATISTICAL ANALYSIS

- **Data distribution:** Shapiro-Wilk's W test: **Variables** significantly skewed were **log transformed** to normality.
- **Intra-group comparisons: Student's t-test** for **paired values** obtained at week 0 and week 12; and at week 0 and week 20.
- **Dunnett's test** was used for **analysis** of the **multiple comparisons** at weeks 4, 8, 12, 16 and 20 with week 0.
- **Inter-group comparisons:** ANOVA. Confounding variables - **ANCOVA analysis** was **performed adjusting** for the **confounding variable + post hoc analysis** (Tukey HSD test).
- A level of **P< 0.05** was set as statistically **significant**.



STUDY PARTICIPANTS

Baseline physical and biochemical characteristics of study participants

Parameter	Non-MetSV (n=9)	MetSV (n=9)	MetSL (n=7)	MetSV + MetSL (n=16)a
Waist circumference (cm)	104 (13.0)	111 (11.9)	116 (27.2)*	116 (20.8)*
Systolic bp (mmHg)	120 ± 11.1	134 ± 14.2	144 ± 8.52**	138 ± 12.6**
Diastolic bp (mmHg)	80.0 ± 6.61	88.3 ± 6.61	89.3 ± 9.32	88.8 ± 7.64*
Fasting glucose ($mmol.L^{-1}$)	5.10 (0.40)	4.80 (0.60)	5.90 (0.61)†	5.25 (1.25)
Fasting insulin ($\mu U.ml^{-1}$)	8.51 ± 1.40	11.1 ± 4.78	14.3 ± 2.82*	12.6 ± 4.20*
30 min insulin ($\mu U.ml^{-1}$)	33.9 (26.4)	73.2 (19.2)	91.3 (38.1)*	74.0 (38.0)*
HOMA index	1.97 (0.48)	2.32 (0.97)	3.26 (1.61)*	2.83 (2.13)*
VO2 Peak ($ml.min\text{-}1.kg^{-1}$)	33.8 ± 5.14	29.3 ± 7.07	23.5 ± 2.59*	26.8 ± 6.18*

Data reported as median (IQR) or mean ± SD

*p<0.05, **p<0.005 vs Non-MetSV; †p<0.05 vs MetSV; aMetSV and MetSL groups were combined and compared with Non-MetS V group

INTRA-GROUP RESULTS
(SIGNIFICANT CHANGES ONLY)

Changes in physical, physiological and metabolic parameters at weeks 4, 8, 12, 16 and 20 for Non-MetSV, MetSV and MetSL groups

Variable	Group	Comparison of baseline data with data at weeks 4, 8 and 12[a]				Comparison of baseline data with data at weeks 16 and 20[b]		
		Baseline[c]	Week 4	Week 8	Week 12	Baseline[d]	Week 16	Week 20
BMI	Non-MetSV	31.0 (6.10)	-	-	29.3 (4.70)*	31.1 (5.80)	-	29.9 (4.30)*
	MetSV	31.8 (4.80)	-	-	29.8 (5.60)*	29.4 (1.10)	-	28.5 (0.10)*
	MetSL	33.9 (11.1)	-	-	32.0 (11.1)*	35.9 (11.1)	-	33.5 (11.4)*
Waist (cm)	Non-MetSV	104 (13.2)	104 (10.0)	103 (10.5)	103 (8.60)	105 (13.3)	101 (12.0)*	102 (12.7)*
	MetSV	111 (11.9)	110 (14.0)	107 (10.7)	107 (11.5)*	110 (18.6)	107 (14.7)	107 (14.1)
	MetSL	116 (27.2)	115 (26.1)*	114 (25.3)*	113 (27.5)*	121 (27.2)	115 (28.1)*	114 (27.0)*
VO2 peak ($ml.min^{-1}.kg^{-1}$)	Non-MetSV	33.8±5.10	34.1±4.61	35.6±3.82	36.3±4.21	33.8±5.50	35.9±3.36	37.0±5.32
	MetSV	29.3±7.10	31.9±6.50	33.9±6.20*	36.6±7.70*	33.8±5.62	41.3±6.90*	44.0±7.60*
	MetSL	23.5±2.61	26.8±5.75	27.7±4.62	29.2±5.34	22.8±2.17	29.6±4.25*	30.8±4.90*
Velocity at AT ($km.h^{-1}$)	Non-MetSV	5.37±0.74	5.91±0.69*	5.95±0.61*	6.22±0.73*	5.30±0.72	6.22±0.78*	6.31±0.73*
	MetSV	5.27±1.53	5.60±1.19	6.03±1.33*	6.09±1.34*	5.94±1.43	6.92±2.02	6.90±1.64*
	MetSL	5.06±0.65	5.36±0.79	5.67±0.64	5.93±0.91*	4.91±0.56	5.87±0.53*	5.89±0.75*
Diastolic BP (mmHg)	Non-MetSV	80.0±6.61	-	-	79.4±9.50	81.3±5.82	-	78.8±6.41
	MetSV	88.3±6.61	-	-	84.1±4.70*	88.1±7.58	-	78.0±8.37*
	MetSL	89.3±9.32	-	-	80.7±9.76*	89.2±10.2	-	77.5±7.58*

INTRA-GROUP RESULTS
(SIGNIFICANT CHANGES ONLY)

Variable	Group	Comparison of baseline data with data at weeks 4, 8 and 12[a]				Comparison of baseline data with data at weeks 16 and 20[b]		
		Baseline[c]	Week 4	Week 8	Week 12	Baseline[d]	Week 16	Week 20
Systolic BP (mmHg)	Non-MetSV	120±11.1	-	-	123±10.8	120±11.8	-	120±8.86
	MetSV	134±14.2	-	-	128±9.28	132±16.4	-	120±23.5
	MetSL	143±8.52	-	-	130±10.6*	144±9.17	-	127±13.3*
Fasting insulin ($\mu U.ml^{-1}$)	Non-MetSV	8.51±1.40	-	-	8.01±4.34	8.70±1.37	-	9.26±5.98
	MetSV	11.1±4.78	-	-	9.23±3.56	10.3±1.48	-	7.04±2.56*
	MetSL	14.3 ± 2.82	-	-	10.3 ± 4.12	14.7 ± 2.93	-	11.4 ± 5.29
HOMA	Non-MetSV	1.97 (0.48)	-	-	1.65 (0.72)	1.99 (0.57)	-	1.96 (0.84)
	MetSV	2.32 (0.97)	-	-	1.53 (1.36)	2.09 (0.48)	-	1.53 (0.26)*
	MetSL	3.26 (1.61)	-	-	2.29 (0.82)	3.82 (1.61)	-	2.04 (0.89)

Data given as mean ± SD or median (interquartile range); Non-MetSV=subjects without metabolic syndrome training at AT; MetSV= subjects with metabolic syndrome training at AT; MetSL= subjects with metabolic syndrome training with walking programme; [a]n for Non-MetSV, MetSV and MetSL groups are 9, 9 and 7, respectively; [b]n for Non-MetSV, MetSV and MetSL groups are 8, 5 and 6, respectively; [c]these values used in Dunnett's against weeks 4, 8 and 12; [d]these values used in Dunnett's test against weeks 16 and 20; *$p<0.05$ vs baseline

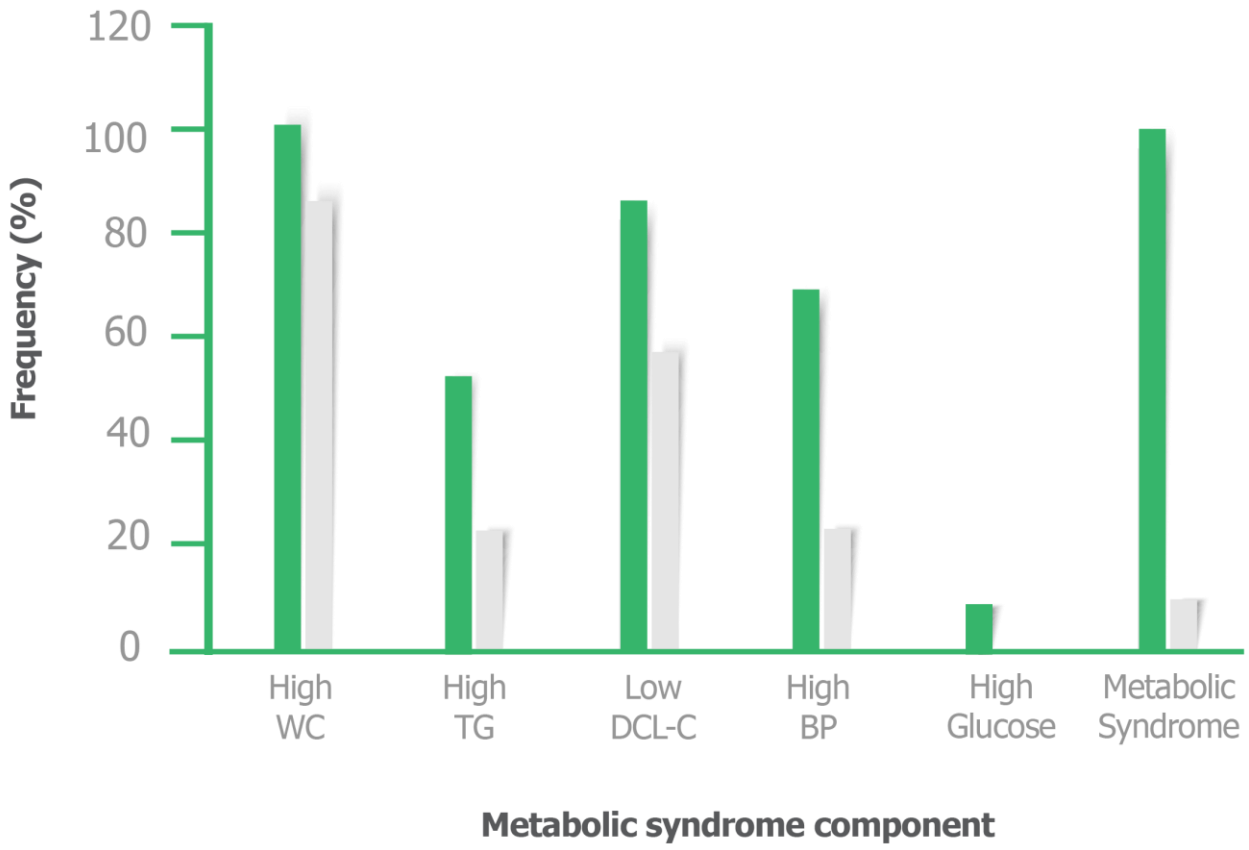
INTER-GROUP COMPARISONS:

Comparison of week 0 vs week 20, percent change data across the three subject groups.

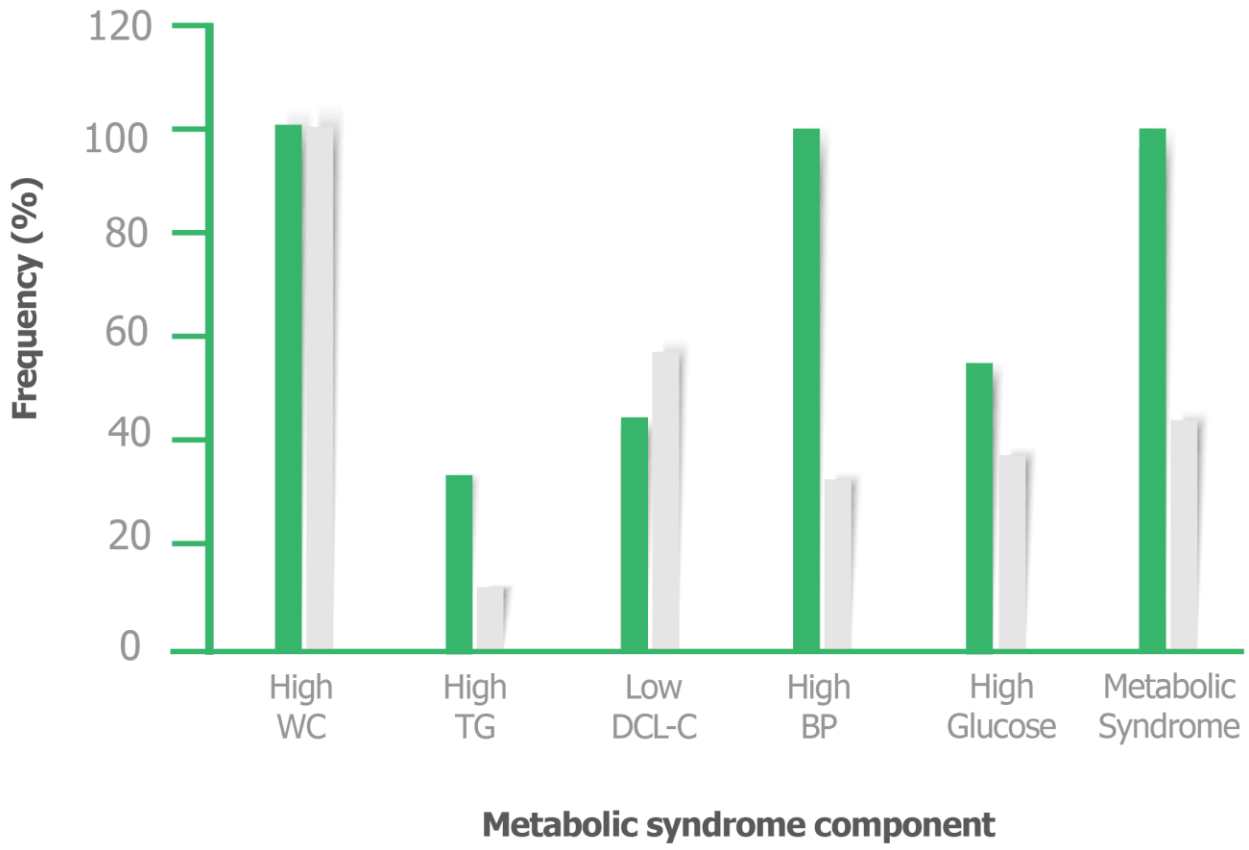
Variables	Non-MetSV (n=8)	MetSV (n=5)	MetSL (n=6)
Body mass	-3.40 ± 3.61	-4.26 ± 1.36	-8.66 ± 4.99*
BMI	-3.39 ± 3.42	-4.23 ± 1.36	-8.67 ± 4.97*
Waist circumference	-3.42 ± 2.45	-3.86 ± 3.05	-6.21 ± 2.94
Triglycerides	-11.5 ± 33.7	-35.7 ± 35.1	-8.68 ± 21.1
Total Cholesterol	1.51 ± 16.3	-18.3 ± 19.7	-4.02 ± 16.9
LDL	3.82 ± 27.3	-20.7 ± 20.4	-5.12 ± 20.9
HDL	6.16 ± 14.9	16.4 ± 17.7	3.87 ± 10.5
Systolic bp	-0.12 ± 6.85	-9.36 ± 10.1	-11.9 ± 9.79*
Diastolic bp	-3.03 ± 4.66	-11.2 ± 8.92	-12.6 ± 7.58*
Fasting glucose	1.92 (-0.46)	4.35 (1.92)	-11.4 (-17.2)
30 min glucose	5.48 ± 27.6	-5.17 ± 25.6	-4.97 ± 15.1
2 hour glucose	-7.79 (-22.1)	21.6 (25.3)	-14.9 (-45.9)
Fasting insulin	-18.5 (-30.7)	-35.3 (-43.8)	-33.3 (-39.8)
30 min insulin	20.4 (-40.8)	-31.4 (-42.5)	2.94 (-2.76)
2 hour insulin	-1.79 ± 47.6	16.6 ± 77.9	8.09 ± 84.9
HOMA index	-18.7 (-31.6)	-32.6 (-35.7)	-37.7 (-47.5)
VO2 Peak	10.7 ± 13.5	30.5 ± 12.8	35.3 ± 18.7*
Velocity at AT	19.6 ± 7.79	16.1 ± 8.05	20.3 ± 11.8

Data reported as a mean ± SD or median (IQR); Non-MetSV=subjects without metabolic syndrome training at AT; MetSV= subjects with metabolic syndrome training at AT; MetSL= subjects with metabolic syndrome training with walking programme; *p<0.05 vs Non-MetSV

INCIDENCE OF MetS AND MetS COMPONENTS: MetSV GROUP



INCIDENCE OF MetS AND MetS COMPONENTS: MetSV GROUP



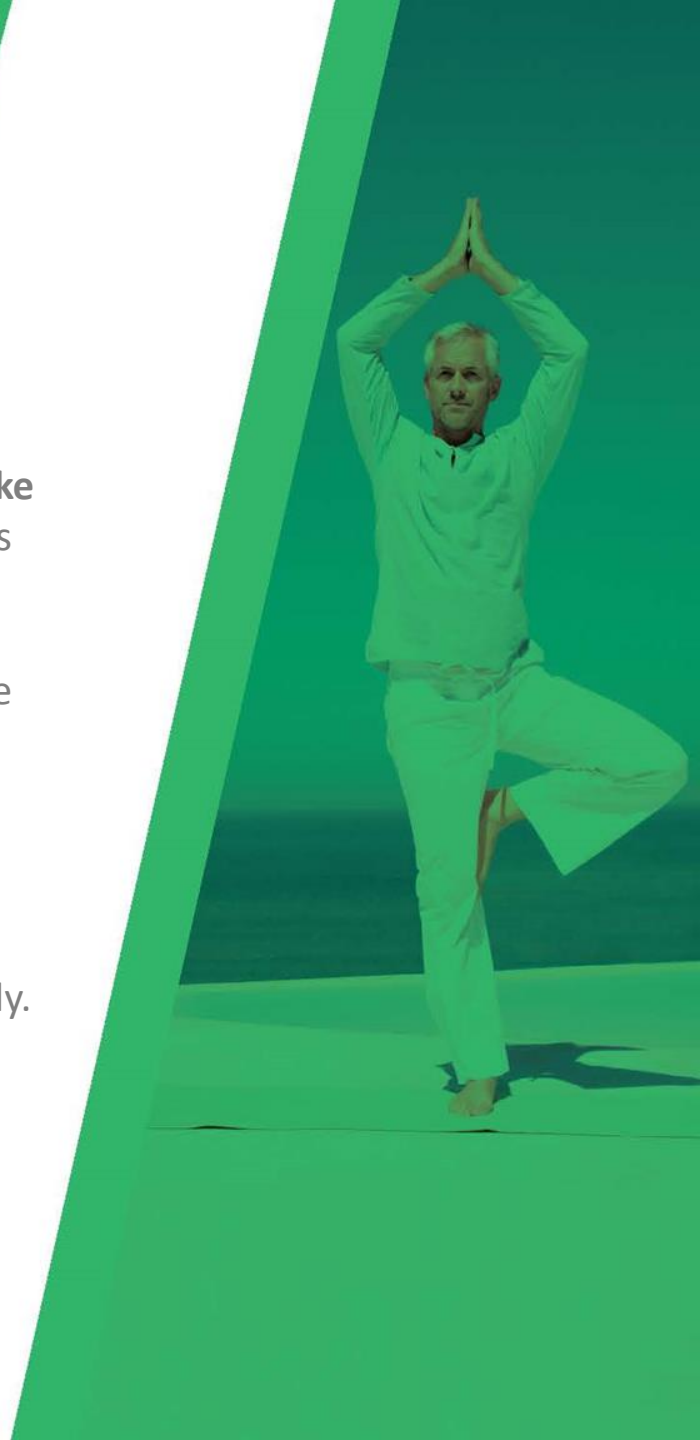
NUTRITIONAL INTAKE & EXERCISE EXPENDITURE ANALYSIS

- No significant **changes in total dietary caloric intake** were noted within each group during the 20 weeks of the study.

- Total dietary caloric intake **did not differ** across the three groups at baseline, week 8 or week 20.

- The MetSL group expended 3994 ± 1089 kcal/wk
- The **MetSV and Non-MetSV** groups expended 1238 ± 173 kcal/wk ($p<0.005$ vs MetSL) and 1110 ± 280 kcal/wk ($p<0.005$ vs MetSL) respectively.

- The Non-MetSV and MetSV groups did **not significantly** differ in exercise energy expenditure.



DISCUSSION

- Both training programmes used in this study showed **favourable training responses** in **physical, physiological and bio-chemical parameters.**
- There was **no significant difference** in the **% change of weight, BMI, waist circumference, blood pressure, peak oxygen consumption, velocity at AT across the two different training groups** (MetSV and MetSL).
- This indicates that the **training programme utilising AT** had a **similar effect on these variables** with **persons with MetS** as the training **programme not using AT.**



DISCUSSION

- **YET**, the training programme **using AT achieved** these **improvement** at a **third of the exercise energy expenditure of the training programme not using AT.**
- The study also found a **dose-response** with respect to **weight loss.**
- At 19 kcal.kg^{-1}.wk^{-1} and 36 kcal.kg^{-1}.wk^{-1} **energy expenditure for the MetSV and MetSL groups** respectively, the **weight loss was 4.3% and 8.7%** respectively at week 20.



DISCUSSION

Biochemical/metabolic parameters

- The training **group with MetS** that **used AT** was the **only group to show significant, positive changes in metabolic parameters** (fasting insulin and HOMA).
- Thus, **insulin sensitivity** may have been **positively influenced** by the **training programme using AT to set intensity.**
- **More specific tests** and a greater number of **subjects** would be needed to **confirm this result.**



INSULIN SENSITIVITY



- **Speculated:** Exercise **training at the AT may improve insulin sensitivity** due to increases in Glut-4 transports **related to an increase in the demand for glucose** when training at the AT.
- This speculation is based on the finding: **Exercise increases the Glut-4 isoform** of the **glucose transporter** which in turn results in a **more rapid glucose uptake** (Holloszy, 2008).
- This **speculation** will need to be addressed with further research.



CONCLUSIONS

- An **endurance exercise programme using AT** to set **intensity** is effective in eliciting **favourable responses in individuals diagnosed with MetS.**
- The **programme** is as effective as the walking programme (not using AT), yet it is **more time-efficient**.
- **Similar results** were achieved with **both training programmes** but the program using **AT** elicited the **responses with a reduced exercise frequency and intensity.**
- Programme **using AT improved insulin sensitivity** which was **not affected** by the **walking programme**.



CONCLUSIONS

- The training programme **using AT indicated** a **reversal of disease** and at a **lower exercise energy expenditure** than that of a training programme **not using AT.**

- Exercise was an **effective medicine** in **reversing MetS**



LIMITATIONS

All subjects were white males, and thus it cannot be assumed that the results will be the same for other ethnic groups and/or females.

- **Small sample sizes** - low numbers in each group.
- Despite this limitation we were able to pick up **significant trends in the data.**
- **No non-exercising control group** and a **group without MetS** that undertook the Leon et al, exercise programme - (These groups were originally included in the study, yet had to be removed due to financial constraints).
- The **nutritional intervention** was **not performed intensively.**



ACKNOWLEDGEMENTS

