VII
西オーストラリア
大学
(スポーツ科学)

11/25・26/2008

University of
Western Australia
(Sports Science)

西オーストラリア大学のスポーツ科学分野との学術交流会
「スポーツ科学の研究・教育交流と国際研究の動向」

【11 月 25 日】

1．スポーツ科学分野での国際交流内容の検討（11：00〜12：00，D204）

2．研究交流会（13：30〜17：00，大会議室）

1) Lecture

Dr. Daniel J Green

Research Institute for Sport and Exercise Sciences, Liverpool John Moores University

School of Sport Science, Exercise and Health, The University of Western Australia

Title: Exercise as vascular medicine

2) Presentations

(1) Dr. Ooue Anna (PD in Graduate School of Human Development and Environment, Kobe University)

Title: Comparison of blood flow in conduit arteries and veins in the upper arm during passive heating and leg exercises in humans

(2) Jian Lin (Student of Master Course in Graduate School of Human Development and Environment, Kobe University)

Title: Thermoregulatory responses during prolonged intermittent exercise at medium intensity

(3) Tatsuro Amano (Undergraduate in Faculty of Human Development, Kobe University)

Title: The heat loss responses to isometric exercise under mildly hyperthermic conditions in sprinters and distance runners

(4) Nobuko Harada (MA in Graduate School of Human Development and Environment, Kobe University)

Title: The effects of a dual-task on step reaction to soft surface ground in older adults

【11 月 26 日】

1．授業への参加と交流（8：50〜10：20，B108）

身体的応論の授業に参加していただいた.

2．大学院生によるフィールドワーク（11：00〜夕方）

参加スタッフ院生の感想

西オーストラリア大学とのスポーツ交流会では事前英語発表資料の作成や発表の練習，また，研究会の準備や資料作成がかなり大変だったが，これらでプログラム作成に必要な様々な能力が身についた．研究室での交流を通して，西オーストラリア大学の歴史や現状を知るだけでなく，英語コミュニケーションによいチャンスを得てた．また，発表時に英語への不安や緊張感などのいろいろな意味で刺激を受けたが，英語発表経験を積む上ではよいと思う．さらに，研究者から自分の研究に対するコメントをいただくのは，これからの研究の発展にも役立つと考えられる．

（林建　人間発達環境学研究科）




EXERCISE AS VASCULAR MEDICINE

Professor Daniel J Green PhD
School of Sport Science, Exercise and Health, The University of Western Australia

講演要旨
運動は，心臓血管系リスクの減少に約30%貢献しており，これは降圧剤や低カロリーなどの薬物療法と同じくらいの効果である．しかし，運動が心臓血管系リスクファクターに及ぼす影響は相対的にはあまり高くない．したがって，心臓血管系を守る運動効果の他の説明が必要である．循環血液と動脈壁の間にある血管内皮は多数の傍分泌（分泌されたホルモンなどが近傍の細胞に作用する様式）ホルモンを産生し，それはアテローム産生を抑制する．内皮の機能異常は血管病の初期で複合的な症状と考えることができる．内皮による血管拡張において重要な生理学的刺激は動脈のずり応力である．運動は内皮上のずり応力の増加を繰り返し起こすことで血管へ直接効果を引き起こす．小筋群や大筋群の運動トレーニングは内皮機能の改善に関与することが明らかにされている．また，運動トレーニングは動脈の内腔径の変化や動脈の再構築を引き起こし，これがアテローム血栓のリスク低下に貢献しているかも知れない．血管機能の変化と構造のそれとの関係に関する研究は，運動トレーニングが微小血管に及ぼす影響に関するものとして，ヒトにおいて，新しい研究である．したがって，運動が血管に及ぼす直接的な効果は，運動トレーニングに関連する心臓発作の減少を十分に説明するものである．運動形態の違いがずり応力のパターンに関係することから，血管のずり応力への運動の直接的効果が考慮されれば，運動処方は最適になるかも知れない．

Abstract
Exercise is associated with an approximate 30% benefit in terms of decreased cardiovascular (CV) risk, a magnitude similar to that associated with antihypertensive and lipid lowering drug therapies. The impact of exercise on traditional cardiovascular risk factors is, however, relatively modest. Clearly, other explanations for the cardioprotective benefits of exercise must exist. The vascular endothelium, which forms the interface between the circulating blood and the artery wall, produces numerous paracrine hormones which are anti-atherogenic. Endothelial *dys*function can be considered an early and integral manifestation of vascular disease. An important physiological stimulus to endothelium-mediated vasodilation is arterial shear stress. Exercise exerts direct effects on the vasculature via the impact of repetitive increases in shear stress on the endothelium. There is strong evidence that exercise training of small and large muscle groups is associated with improvement in endothelial function. Exercise training also induces changes in artery lumen diameter, arterial remodelling, which may contribute to decreased atherothrombotic risk. Studies of the relationship between changes in artery function and structure in humans are now emerging, as is information relating to the impact of exercise training in microvessels. A direct effect of exercise on the vasculature therefore provides a plausible explanation for the reduction in cardiac events associated with exercise training. Since different forms of exercise are associated with distinct patterns of shear stress, it is likely that exercise prescription may be optimised if the direct effects of exercise on vascular shear stress are taken into consideration.

Changes in Vascular Function and Structure Following Exercise Training

Exercise as Vascular Medicine

Professor Daniel J Green

Liverpool John Moores University, United Kingdom and The University of Western Australia, Perth

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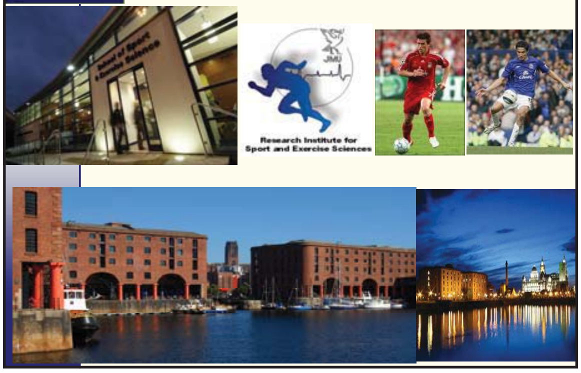
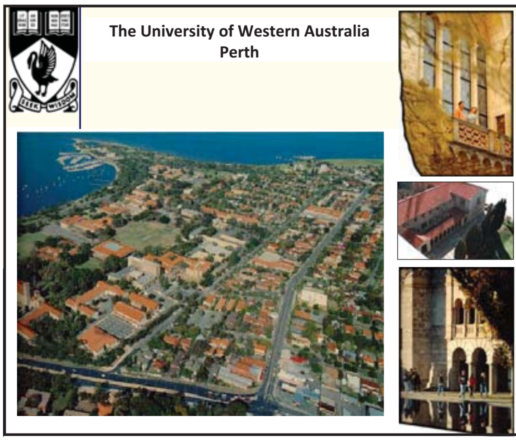
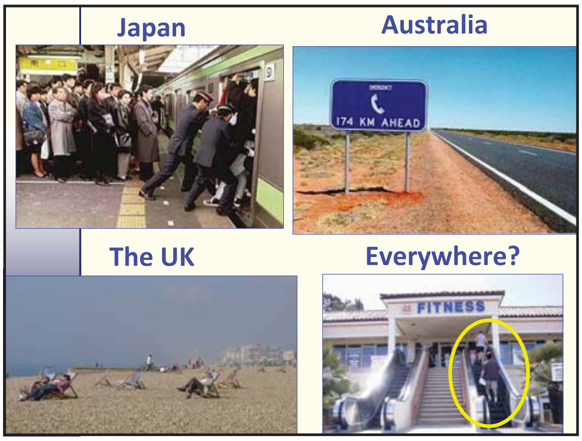
Research Institute for Sport and Exercise Sciences
Liverpool John Moores University

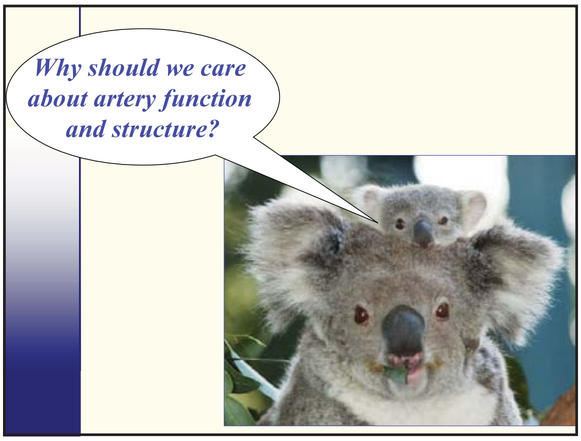


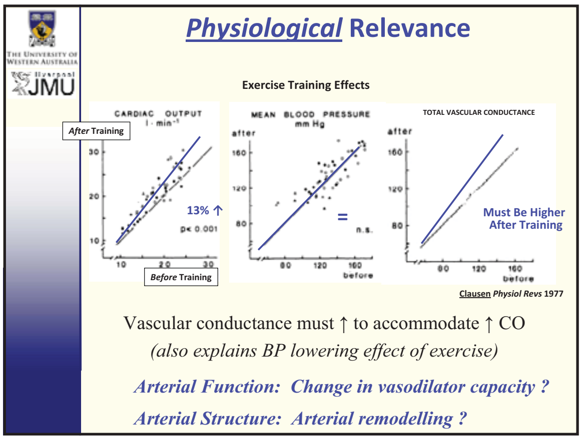
The University of Western Australia
Perth

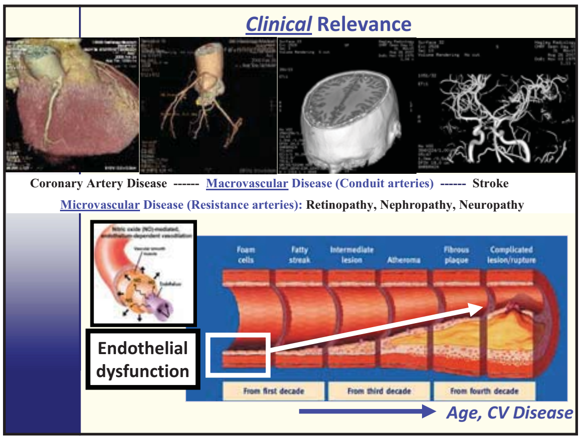


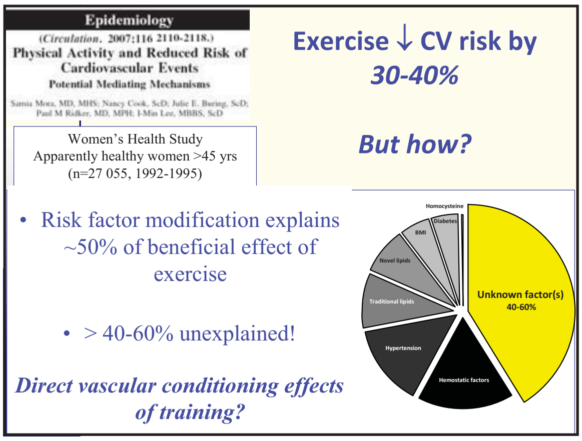
School of Sports Science, Exercise, Health
University of Western Australia, Perth

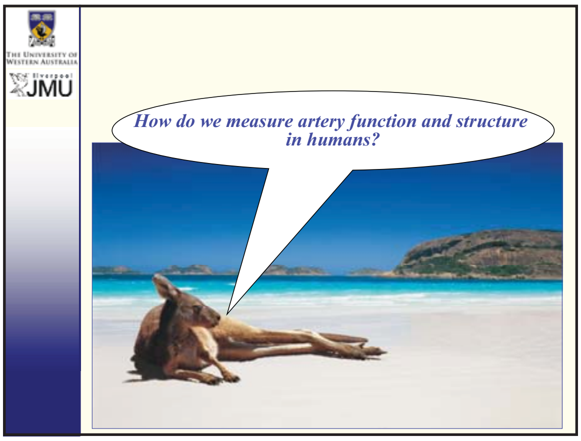


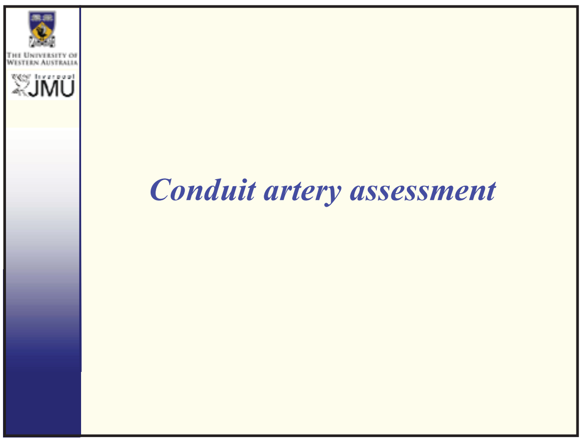


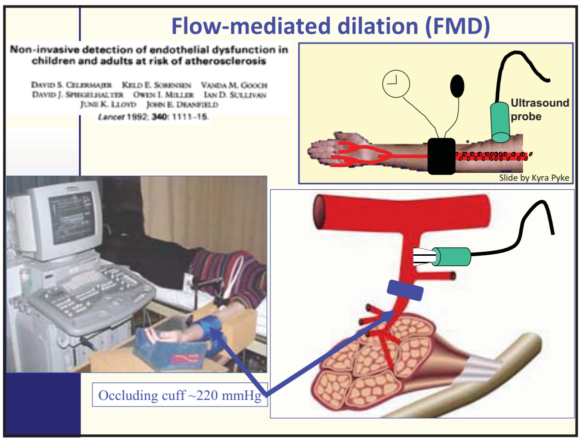

Physiological Relevance
Exercise Training Effects
CARDIAC OUTPUT
After Training
13% ↑
p< 0.001
Before Training
MEAN BLOOD PRESSURE
mm Hg
after
before
=
n.s.
TOTAL VASCULAR CONDUCTANCE
Must Be Higher
After Training
Clausen Physiol Revs 1977
Vascular conductance must ↑ to accommodate ↑ CO
(also explains BP lowering effect of exercise)
Arterial Function: Change in vasodilator capacity ?
Arterial Structure: Arterial remodelling ?

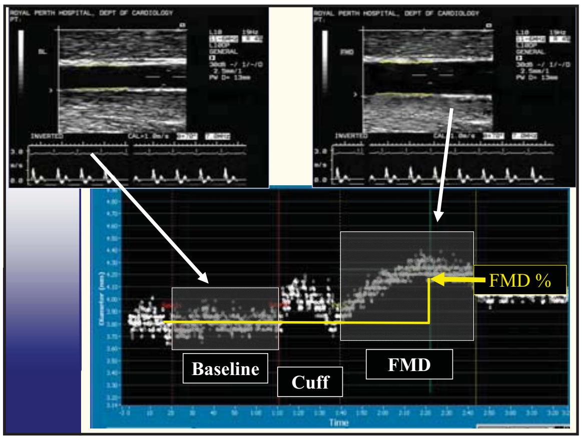

Clinical Relevance
Coronary Artery Disease ------ Macrovascular Disease (Conduit arteries) ------ Stroke
Microvascular Disease (Resistance arteries): Retinopathy, Nephropathy, Neuropathy
Foam cells
Fatty streak
Intermediate lesion
Atheroma
Fibrous plaque
Complicated lesion/rupture
Endothelial dysfunction
From first decade
From third decade
From fourth decade
Age, CV Disease


Epidemiology
(Circulation. 2007;116 2110-2118.)
Physical Activity and Reduced Risk of Cardiovascular Events
Potential Mediating Mechanisms
Samia Mora, MD, MHS; Nancy Cook, ScD; Julie E. Buring, ScD; Paul M Ridker, MD, MPH; I-Min Lee, MBBS, ScD
Women's Health Study
Apparently healthy women >45 yrs
(n=27 055, 1992-1995)
Exercise ↓ CV risk by 30-40%
But how?
Risk factor modification explains ~50% of beneficial effect of exercise
> 40-60% unexplained!
Direct vascular conditioning effects of training?
Homocysteine
Diabetes
BMI
Novel lipids
Traditional lipids
Hypertension
Hemostatic factors
Unknown factor(s) 40-60%

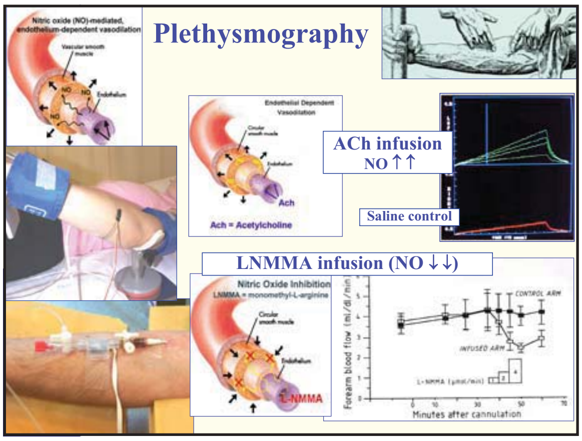

How do we measure artery function and structure in humans?

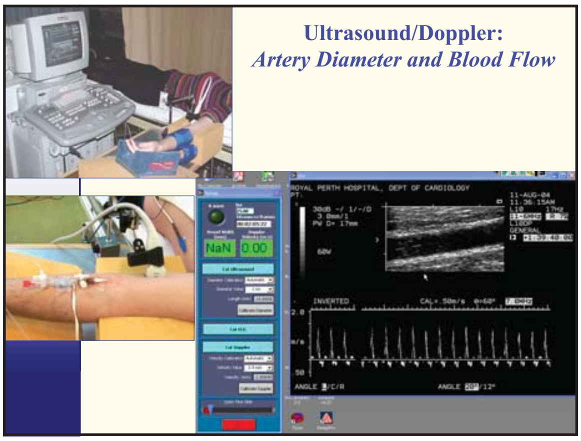

Conduit artery assessment

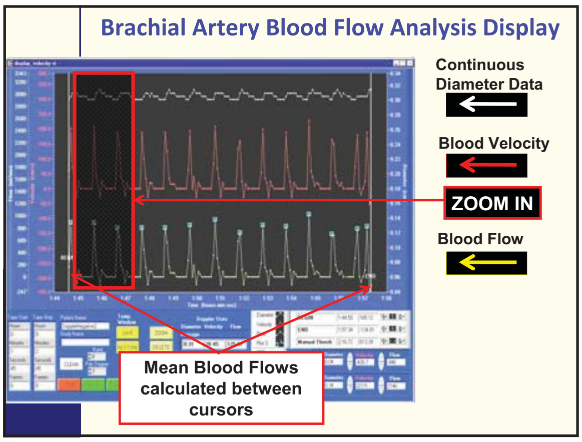

Flow-mediated dilation (FMD)
Non-invasive detection of endothelial dysfunction in children and adults at risk of atherosclerosis
David S. Celermajer Keld E. Sorensen Vanda M. Gooch
David J. Spiegelhalter Owen I. Miller Ian D. Sullivan
June K. Lloyd John E. Deanfield
Lancet 1992; 340: 1111-15.
Ultrasound probe
Slide by Kyra Pyke
Occluding cuff ~220 mmHg

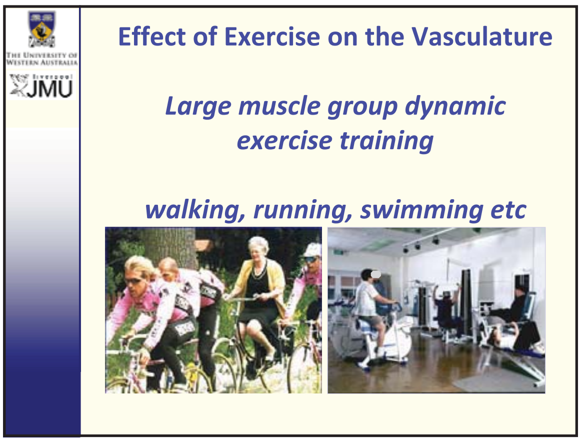


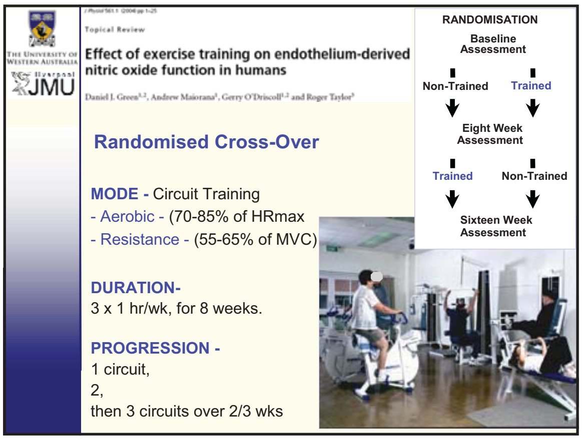
Resistance artery assessments

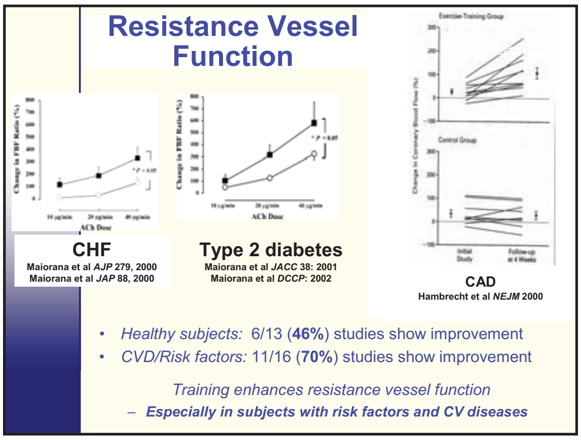


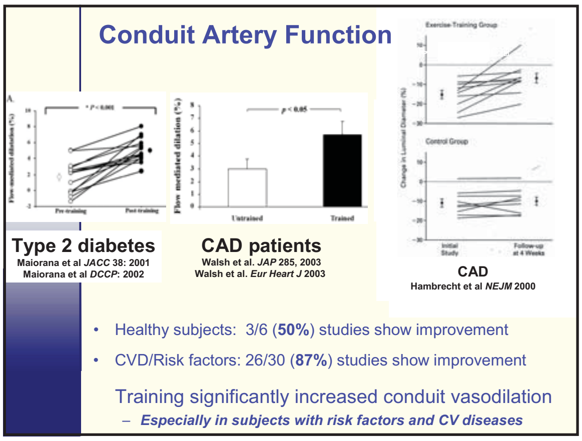


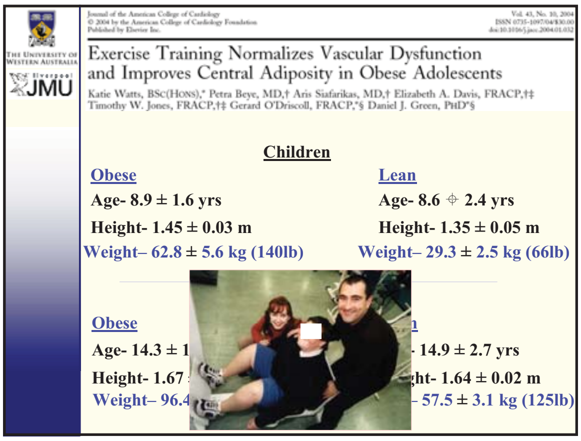





THE UNIVERSITY OF WESTERN AUSTRALIA
JMU
Effect of exercise training on endothelium-derived nitric oxide function in humans
Randomised Cross-Over
MODE - Circuit Training
- Aerobic - (70-85% of HRmax
- Resistance - (55-65% of MVC)
DURATION-
3 x 1 hr/wk, for 8 weeks.
PROGRESSION -
1 circuit,
2,
then 3 circuits over 2/3 wks
RANDOMISATION
Baseline Assessment
Non-Trained
Trained
Eight Week Assessment
Trained
Non-Trained
Sixteen Week Assessment


Resistance Vessel Function
CHF
Maiorana et al AJP 279, 2000
Maiorana et al JAP 88, 2000
Type 2 diabetes
Maiorana et al JACC 38: 2001
Maiorana et al DCCP: 2002
CAD
Hambrecht et al NEJM 2000
Healthy subjects: 6/13 (46%) studies show improvement
CVD/Risk factors: 11/16 (70%) studies show improvement
Training enhances resistance vessel function
– Especially in subjects with risk factors and CV diseases


Conduit Artery Function
Type 2 diabetes
Maiorana et al JACC 38: 2001
Maiorana et al DCCP: 2002
CAD patients
Walsh et al. JAP 285, 2003
Walsh et al. Eur Heart J 2003
CAD
Hambrecht et al NEJM 2000
Healthy subjects: 3/6 (50%) studies show improvement
CVD/Risk factors: 26/30 (87%) studies show improvement
Training significantly increased conduit vasodilation
– Especially in subjects with risk factors and CV diseases


THE UNIVERSITY OF WESTERN AUSTRALIA
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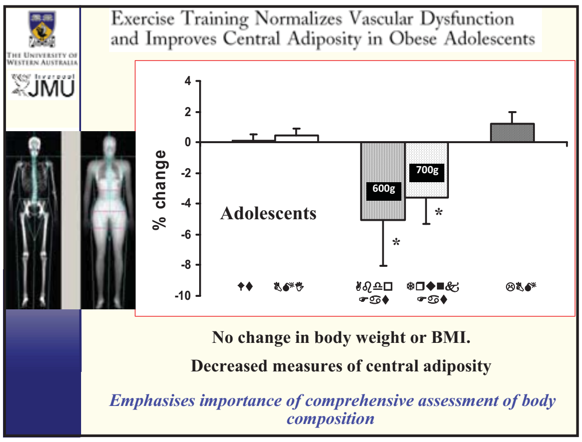
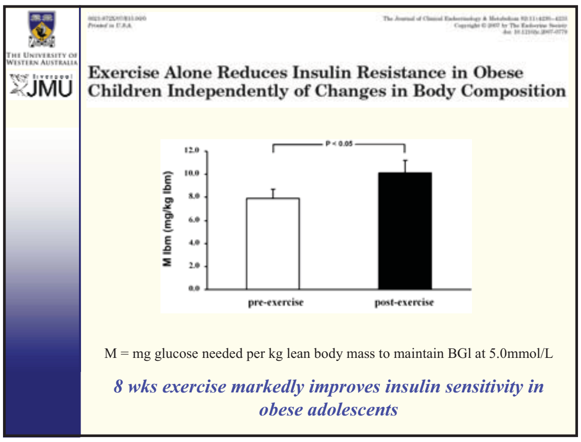
Exercise Training Normalizes Vascular Dysfunction and Improves Central Adiposity in Obese Adolescents
Children
Obese
Age- 8.9 ± 1.6 yrs
Height- 1.45 ± 0.03 m
Weight– 62.8 ± 5.6 kg (140lb)
Lean
Age- 8.6 ± 2.4 yrs
Height- 1.35 ± 0.05 m
Weight– 29.3 ± 2.5 kg (66lb)
Obese
Age- 14.3 ± 1
Height- 1.67
Weight– 96.4
14.9 ± 2.7 yrs
ht- 1.64 ± 0.02 m
57.5 ± 3.1 kg (125lb)


THE UNIVERSITY OF WESTERN AUSTRALIA
JMU
Exercise Training Normalizes Vascular Dysfunction and Improves Central Adiposity in Obese Adolescents
% change
Adolescents
600g
700g
No change in body weight or BMI.
Decreased measures of central adiposity
Emphasises importance of comprehensive assessment of body composition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Exercise Alone Reduces Insulin Resistance in Obese Children Independently of Changes in Body Composition
M lbm (mg/kg lbm)
P < 0.05
pre-exercise
post-exercise
M = mg glucose needed per kg lean body mass to maintain BGl at 5.0mmol/L
8 wks exercise markedly improves insulin sensitivity in obese adolescents

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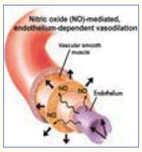
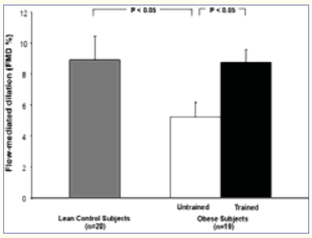
ISSN 0735-1097/04/$30.00
doi:10.1016/j.jacc.2004.01.032

Exercise Training Normalizes Vascular Dysfunction and Improves Central Adiposity in Obese Adolescents

Katie Watts, BSc(Hons),* Petra Beye, MD,† Aris Siafarikas, MD,† Elizabeth A. Davis, FRACP,†‡ Timothy W. Jones, FRACP,†‡ Gerard O'Driscoll, FRACP,*§ Daniel J. Green, PhD*§





Watts et al -

J Pediatrics 2004
JACC 2004
Sports Med 2005
Circ editorial 2003

Exercise training normalises endothelial function in obese children and adolescents

So far ……

- *Large muscle group* dynamic exercise training:

  Enhances coronary and peripheral *resistance* vessel vasodilator function

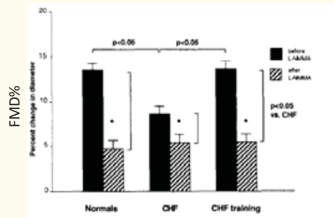
  Enhances coronary and peripheral *conduit* artery vasodilator function

  Effects more evident in subjects with CV disease and risk factors

  Reflex changes or localised effect?

Effect of localised (eg hand-grip) exercise training in humans

Localised Training and Arterial Function



Heart Failure (+ve)

- Hornig *Circ* 1996
- Katz *JAP* 1997
- Hambrecht *JACC* 2000; Circ 1998
- Bank *J Card Fail* 1998

Healthy subjects (~ or –ve):

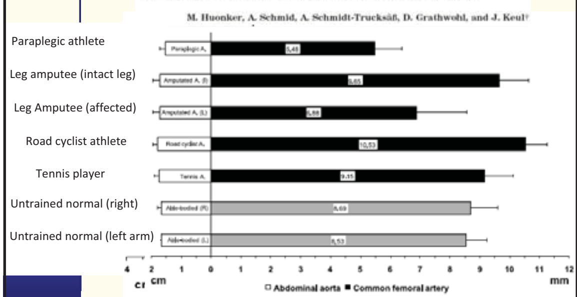
- Green *et al* JAP 1994
- Green *et al* JAP 1996
- Franke *et al Clin Physiol* 1998
- Maiorana *et al* MSSE 2001

Adaptations more readily apparent in subjects with impaired function a priori?

Localised Exercise and *Conduit* Structure/Function

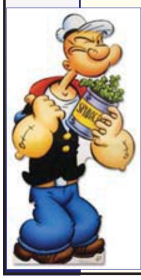
Size and blood flow of central and peripheral arteries in highly trained able-bodied and disabled athletes

M. Huonker, A. Schmid, A. Schmidt-Trucksäß, D. Grathwohl, and J. Keul



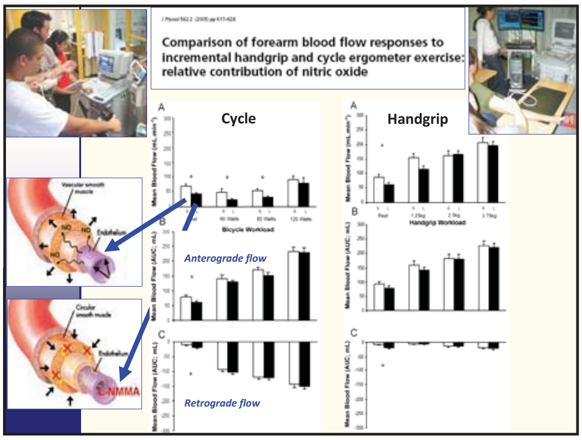
- Large elastic arteries show less adaptation than smaller conduit arteries
- Localised adaptations evident in tennis players, amputees

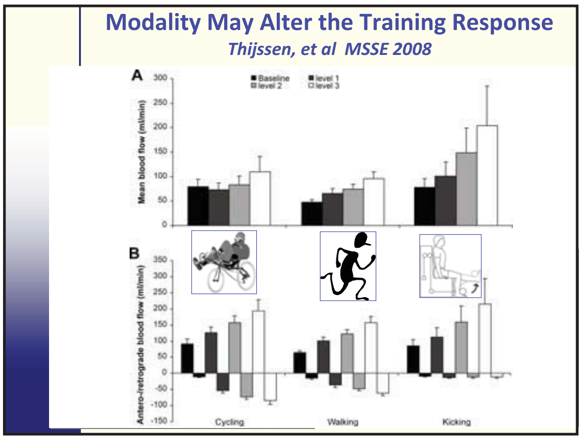
- **Small muscle group training**:
  - Can induce resistance and conduit artery remodelling
  - Evidence for functional adaptations is poor in healthy subjects, but good in CVD
    - ***Function may be more amenable to adaptation in those with initially impaired function***

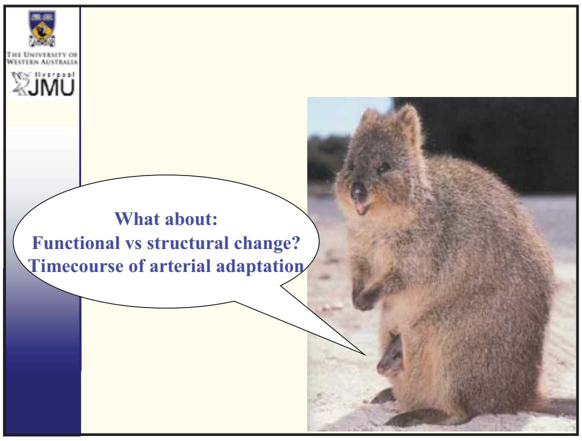


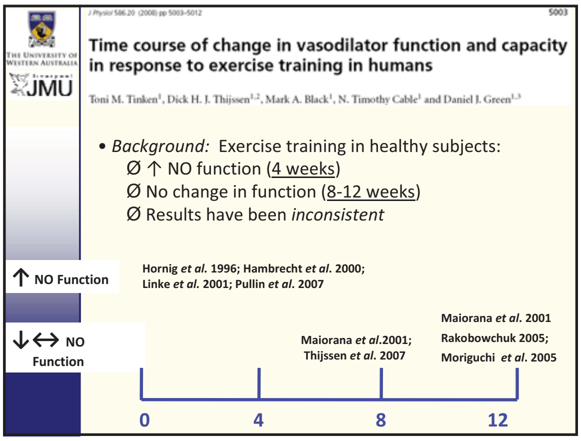
Localised or intrinsic mechanisms since:

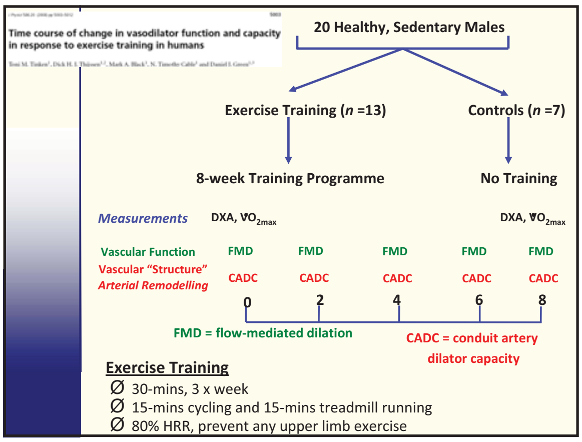
- Unilateral adaptations occur
- Not due to transmural pressure as BP is bilaterally affected
- ***Localised changes in shear stress?***

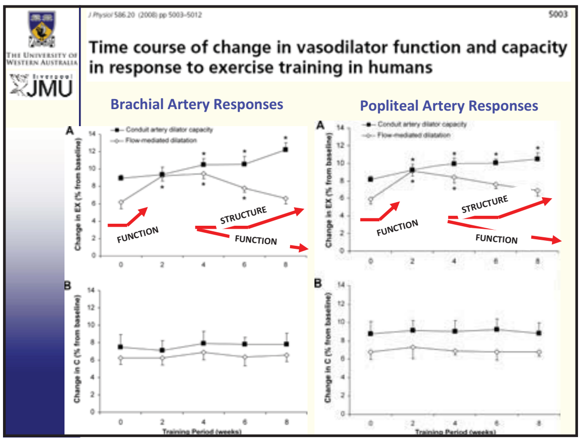

Comparison of forearm blood flow responses to incremental handgrip and cycle ergometer exercise: relative contribution of nitric oxide
Cycle
Handgrip
Anterograde flow
Retrograde flow
Bicycle Workload
Handgrip Workload
L-NMMA


Modality May Alter the Training Response
Thijssen, et al MSSE 2008
Mean blood flow (ml/min)
Antero-/retrograde blood flow (ml/min)
Baseline
level 1
level 2
level 3
Cycling
Walking
Kicking


The University of Western Australia
Liverpool JMU
What about:
Functional vs structural change?
Timecourse of arterial adaptation


The University of Western Australia
Liverpool JMU
J Physiol 586.20 (2008) pp 5003–5012
5003
Time course of change in vasodilator function and capacity in response to exercise training in humans
Toni M. Tinken, Dick H. J. Thijssen, Mark A. Black, N. Timothy Cable and Daniel J. Green
• Background: Exercise training in healthy subjects:
Ø ↑ NO function (4 weeks)
Ø No change in function (8-12 weeks)
Ø Results have been inconsistent
↑ NO Function
Hornig et al. 1996; Hambrecht et al. 2000; Linke et al. 2001; Pullin et al. 2007
↓↔ NO Function
Maiorana et al.2001; Thijssen et al. 2007
Maiorana et al. 2001
Rakobowchuk 2005;
Moriguchi et al. 2005
0
4
8
12


Time course of change in vasodilator function and capacity in response to exercise training in humans
20 Healthy, Sedentary Males
Exercise Training (n =13)
Controls (n =7)
8-week Training Programme
No Training
Measurements
DXA, VO2max
DXA, VO2max
Vascular Function
Vascular "Structure"
Arterial Remodelling
FMD FMD FMD FMD FMD
CADC CADC CADC CADC CADC
0 2 4 6 8
FMD = flow-mediated dilation
CADC = conduit artery dilator capacity
Exercise Training
Ø 30-mins, 3 x week
Ø 15-mins cycling and 15-mins treadmill running
Ø 80% HRR, prevent any upper limb exercise


The University of Western Australia
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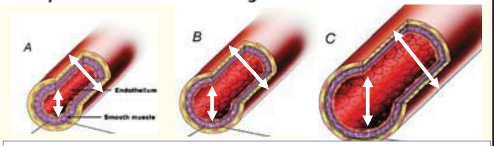
J Physiol 586.20 (2008) pp 5003–5012
5003
Time course of change in vasodilator function and capacity in response to exercise training in humans
Brachial Artery Responses
Popliteal Artery Responses
Conduit artery dilator capacity
Flow-mediated dilatation
FUNCTION
STRUCTURE
FUNCTION
Training Period (weeks)

J Physiol 586.20 (2008) pp 5003–5012 5003

Time course of change in vasodilator function and capacity in response to exercise training in humans



Exercise training and physical activity:

1. Enhance *artery function*

then

2. Enlarge arteries via *remodelling*

Both adaptations decrease atherosclerosis

Does adaptation occur at all levels of the arterial tree?

J Physiol 586.14 (2008) pp 3511–3524 3511

Exercise prevents age-related decline in nitric-oxide-mediated vasodilator function in cutaneous microvessels

Mark A. Black[1], Daniel J. Green[1,2] and N. Timothy Cable[1]

Table 1. Subjects characteristics at baseline

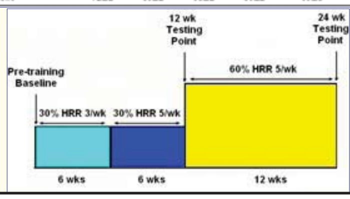
	Young		Sedentary older		Fit older	
	ACh (*n* = 12)	LH (*n* = 12)	ACh (*n* = 18)	LH (*n* = 18)	ACh (*n* = 16)	LH (*n* = 16)
Age (years)	26±1	27±1	59±1†	60±1†‡	58±2	58±1
Body weight (kg)	68±2	69±3	85±4†‡	83±4†‡	65±2	69±3
BMI	23±1	23±1	29±1†‡	29±1†‡	23±1	24±1
DEXA						
Fat mass (kg)	15±2	13±1	26±2†‡	28±2†‡	14±2	15±2
Lean body mass (kg)	52±3	53±3	57±3	54±4	49±2	52±3
% body fat	21±3	20±2	31±2†‡	34±2†‡	21±2	22±2
$\dot{V}_{O_2,max}$ (ml kg^{-1} min^{-1})	50±3	48±3	28±1†‡	28±1†‡	46±3	44±2
Resting blood pressure (mmHg)						
Systolic	109±3	105±3	126±3†	123±5†	124±4†	115±5
Diastolic	66±3	60±1	72±1	70±2†	70±3	67±3

Values are means±S.E.M., †$P < 0.01$ *versus* young subjects, ‡$P < 0.01$ *versus* older fit subjects. LH, local heating protocol; ACh, acetylcholine protocol.

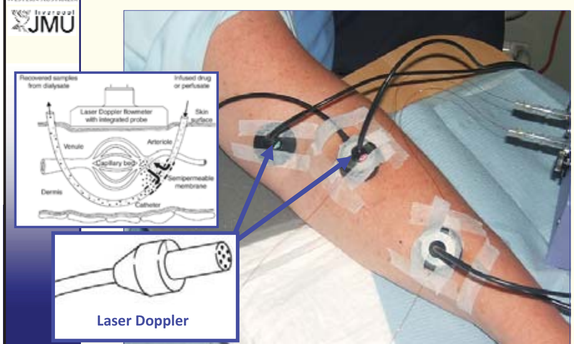
Exercise prevents age-related decline in nitric-oxide-mediated vasodilator function in cutaneous microvessels

Table 2. Changes in characteristics with training in older sedentary individuals

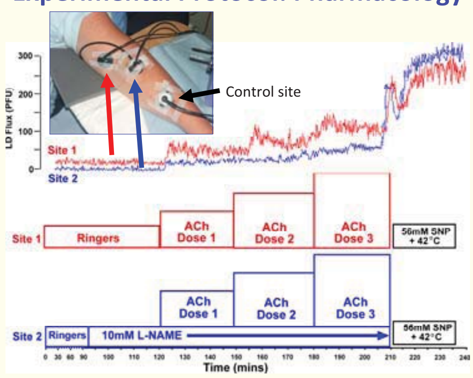
	Entry		12 weeks		24 weeks	
	LH (*n* = 8)	ACh (*n* = 8)	LH (*n* = 8)	ACh (*n* = 8)	LH (*n* = 8)	ACh (*n* = 8)
Body weight (kg)	88±7	82±4	88±7	81±4	87±7	78±3*
BMI	30±2	30±2	30±2	29±1	29±1	28±1*
DEXA						
Fat mass (kg)	29±2	29±3	29±2	28±3	28±2	26±3*
Lean body mass (kg)	57±5	51±4	57±5	51±4	57±6	51±3
% body fat	33±2	35±4	33 + 2	34±3*	32±2	32±3‡
$\dot{V}_{O_2,max}$ (ml kg^{-1} min^{-1})	26±2	27±3	28±1*	29±2*	30±2†‡	34±3†‡
Resting blood pressure (mmHg)						
Systolic	130±6	121±6	121±4	118±5	120±6	118±4
Diastolic	72±2	69±2	68±2	66±2	69±3	64±3

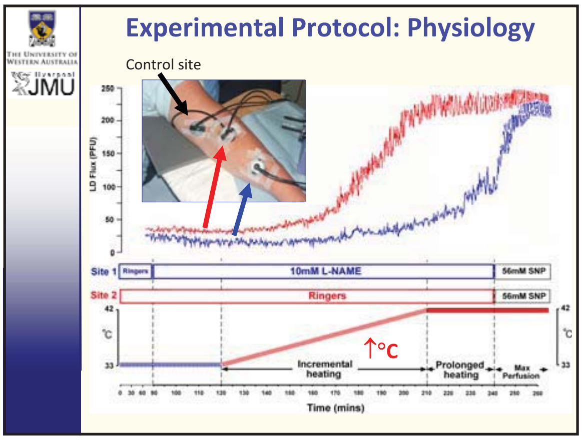


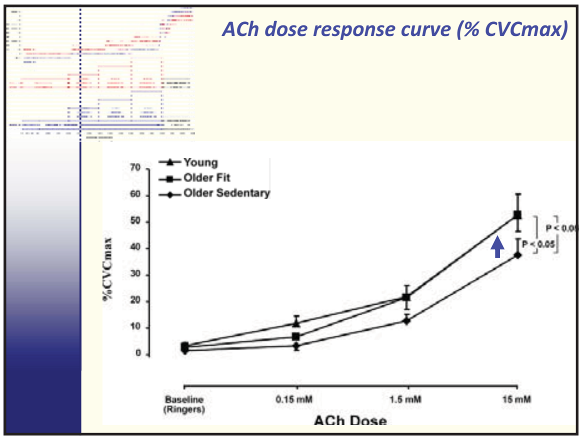
Methods : Microdialysis and Laser Flowmetry

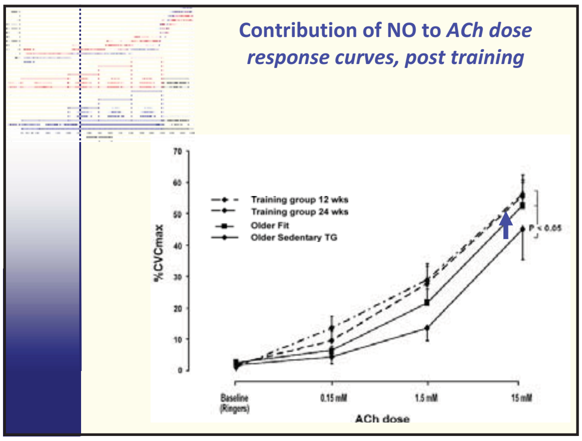


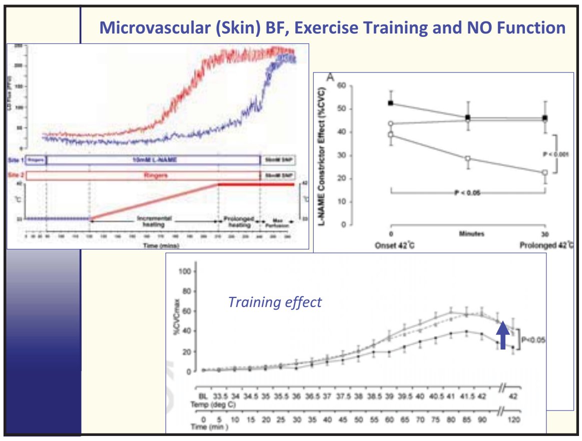
Experimental Protocol: Pharmacology

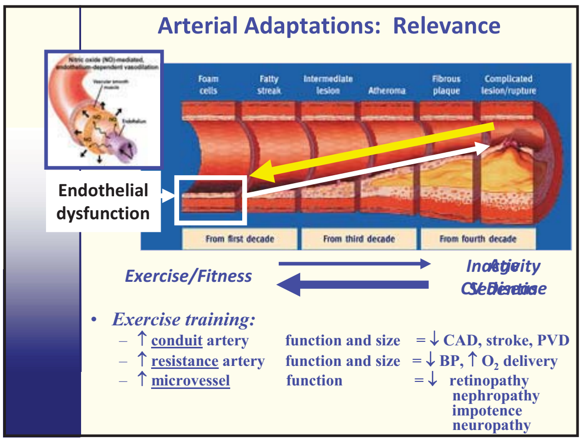



Experimental Protocol: Physiology
Control site
LD Flux (PFU)
Site 1 Ringers 10mM L-NAME 56mM SNP
Site 2 Ringers 56mM SNP
↑°C
Incremental heating
Prolonged heating
Max Perfusion
Time (mins)


ACh dose response curve (% CVCmax)
Young
Older Fit
Older Sedentary
%CVCmax
P < 0.05
Baseline (Ringers)
0.15 mM
1.5 mM
15 mM
ACh Dose


Contribution of NO to ACh dose response curves, post training
Training group 12 wks
Training group 24 wks
Older Fit
Older Sedentary TG
%CVCmax
P < 0.05
Baseline (Ringers)
0.15 mM
1.5 mM
15 mM
ACh dose


Microvascular (Skin) BF, Exercise Training and NO Function
L-NAME Constrictor Effect (%CVC)
P < 0.001
P < 0.05
Onset 42°C
Minutes
Prolonged 42°C
Training effect
%CVCmax
P<0.05
Temp (deg C)
Time (min)


Arterial Adaptations: Relevance
Endothelial dysfunction
Foam cells
Fatty streak
Intermediate lesion
Atheroma
Fibrous plaque
Complicated lesion/rupture
From first decade
From third decade
From fourth decade
Exercise/Fitness
Inactivity
Sedentary
Exercise training:
↑ conduit artery function and size = ↓ CAD, stroke, PVD
↑ resistance artery function and size = ↓ BP, ↑ O2 delivery
↑ microvessel function = ↓ retinopathy
nephropathy
impotence
neuropathy


The University of Western Australia
Liverpool JMU
zzzz.....zzzzz......zzzzz

Comparison of blood flow in conduit arteries and veins in the upper arm during passive heating and leg exercises in humans

Anna Ooue
Postdoctoral Research Fellow, Graduate School of Human Development & Environment
Kobe University

Abstract

This study compared the blood flow in the conduit arteries and veins of the upper arm between passive heating and leg exercises by using ultrasound Doppler. In passive heating experiment, hot water was circulated for 20 rested subjects in the supine position to keep the mean skin temperature at 37–38°C for 50 min after the rest for 55 min. In exercise experiment, 14 subjects performed a supine cycling exercise at 60–69% of maximal oxygen uptake for 30 min after the rest for about 55 min. Although blood flow in the conduit artery and superficial vein of the upper arm increased linearly with rising core temperature (ΔT_c) during passive heating, blood flow in these vessels slightly decreased in the early stage of ΔT_c elevation, then increased with a rise in ΔT_c during exercise, so that blood flow was significantly greater during the former condition than the latter at a given ΔT_c ($P < 0.05$). In contrast, blood flow in the deep vein of the upper arm did not change under either condition. Blood flow in the artery depended primarily on the blood velocity, but blood flow in the superficial vein was related to both blood velocity and diameter. Moreover, the mean skin temperature and skin blood flow during passive heating were significantly higher than during exercise at a given ΔT_c ($P < 0.05$). These results suggest that the controls of blood flow in conduit arteries and superficial veins, but not deep veins, are different between passive heating and exercise at a given ΔT_c. This difference is suggested not only to be due to the mean skin temperature but also exercise effects.

安静温熱負荷時と運動時における上腕部導管血管の血流応答特性

大上安奈
神戸大学大学院人間発達環境学研究科

発表要旨

本研究は超音波ドップラー法を用いて上腕部の導管動脈および導管静脈の血流応答を安静温熱負荷時と脚運動時において比較した．20 名の被験者は仰臥位姿勢をとり，安静を約 55 分間保った後，温水を循環させ平均皮膚温を 37−38℃で維持した（50 分間）．別の 14 名の被験者は安静を約 55 分間保った後，60−69$\dot{V}O_{2max}$ 強度の仰臥位自転車運動を 30 分間実施した．上腕部の導管動脈および表在性静脈の血流量は安静温熱負荷時において深部体温上昇に伴い直線的に増大したが，運動時において深部体温上昇初期にわずかに低下した後，深部体温上昇に伴い増大した．そのため，同一深部体温で比較した場合，前者の条件の血流量が後者のそれより有意に大きい値を示した（$P < 0.05$）．一方，上腕部の深在性静脈の血流量はいずれの条件も深部体温上昇に伴い変化しなかった．導管動脈でみられた血流量の条件間の差は血流速度のそれに依存していたが，表在性静脈でみられたそれは血流速度と血管径の両者に関連していた．さらに，同一深部体温で比較した場合，安静温熱負荷時における平均皮膚温および皮膚血流量は脚運動時におけるそれらよりも有意に大きい値を示した（$P < 0.05$）．これらの結果は上腕部の導管動脈および表在性静脈，深在性静脈ではなく，における血流量の調節は安静温熱負荷時と脚運動時で異なることを示唆している．このような条件間の違いは平均皮膚温の差だけではなく運動自体の影響も関連している．

Comparison of blood flow in conduit arteries and veins in the upper arm during passive heating and leg exercises in humans

Anna Ooue, Ph.D.

Laboratory for Applied Human Physiology,
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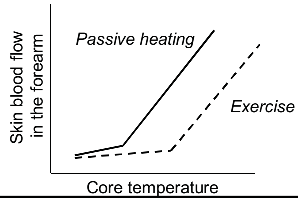
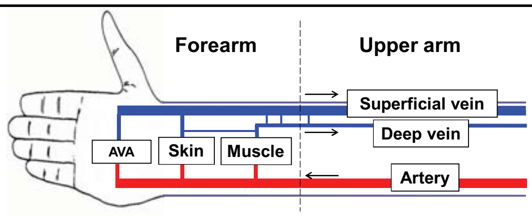
Introduction

During passive heating and exercise, the splanchnic blood flow (BF) and inactive muscle BF are decreased, so that skin blood flow (SkBF) is increased for maintaining core temperature (Tc).

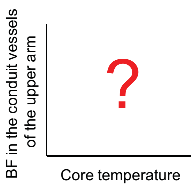
However, BF redistribution during exercise is more complex than during passive heating because of the competition of BF between skin and active muscle. In fact, the pattern of SkBF in the forearm to a rise in Tc is different between two conditions (Johnson and Park 1981; Kellogg et al. 1991).

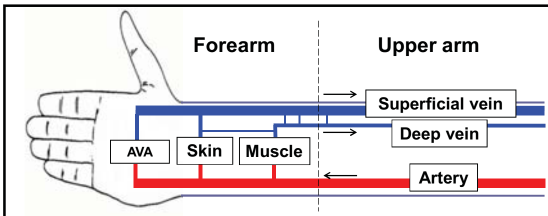




- **Conduit artery** supplies blood to the whole forearm and hand.
- **Superficial vein** returns blood from skin.
- **deep vein** returns blood from muscle.

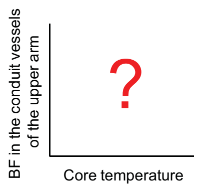
Because SkBF in the forearm during exercise is different from passive heating, BF in conduit vessels of the upper arm, especially artery and superficial vein, may be also different between two conditions. However, it is not clear.





Purpose

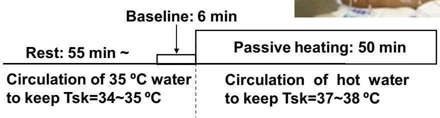
To examine how BF responds in the conduit artery and veins of the upper arm with a rise in Tc during passive heating versus the response during leg exercise.



Methods

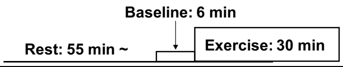
● *Passive heating experiment*

- **Subjects: 15 men and 5 women**
- **Ambient condition: 25 °C, RH 50%**
- **Protocol:**



● *Leg exercise experiment*

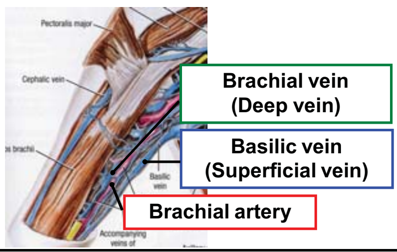
- **Subjects: 12 men and 2 women**
- **Ambient condition: 28 °C, RH 50%**
- **Exercise intensity: 60~69%VO_{2max}**
- **Protocol:**



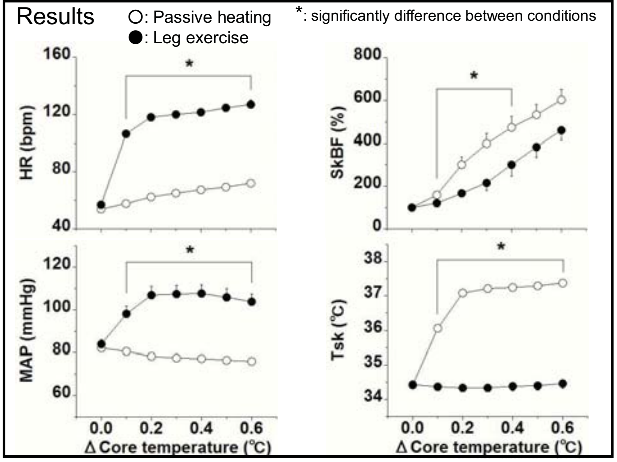
● **Measurements**

- **Core temperature (Tc: esophageal temperature, and oral temperature)**
- **Local skin temperature**
- **Heart rate (HR), and Mean arterial blood pressure (MAP)**
- **Skin blood flow (SkBF) in the forearm (Laser-Doppler velocimetly)**
- **Blood velocity, and vessel diameter in the conduit artery and veins (pulsed and echo Doppler ultrasound)**

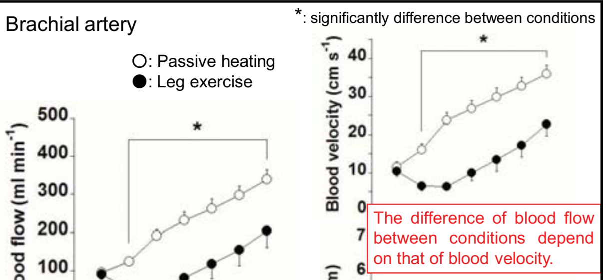
Blood flow (BF) = Blood velocity * (vessel diameter / 2) ^{2} * π



Results

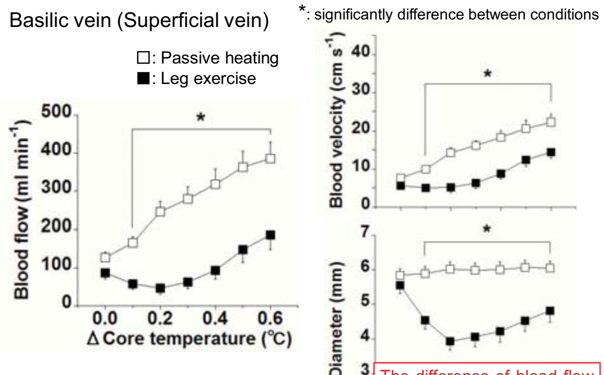


Brachial artery



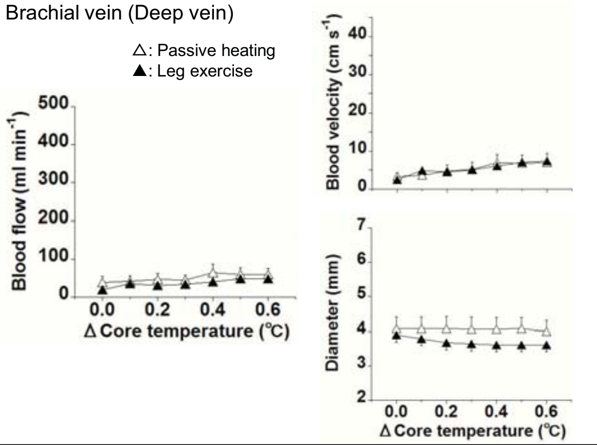
1) The difference of Tsk between conditions (Thermal factor)
2) Effect of exercise itself (Nonthermal factor)

Basilic vein (Superficial vein)



1) The difference of Tsk between conditions (Thermal factor)
2) Effect of exercise itself (Nonthermal factor)

Brachial vein (Deep vein)



Conclusion

1. Changes in and the control of BF in the artery and superficial vein, but not the deep vein, is different between passive heating and exercise, even comparing the BF response versus changing ΔTc.
2. These differences may be induced by not only Tsk, but also exercise effects.

Thermoregulatory responses during prolonged intermittent exercise at the medium intensity

Jian Lin
Graduate School of Human Development & Environment , Kobe University

Abstract

To investigate the thermoregulatory responses during prolonged intermittent exercise at the medium intensity ten healthy male subjects cycled under three different conditions at the same total workload, 1) continuous exercise at 50% maximal oxygen uptake ($\dot{V}O_{2max}$) for 30 min (con-condition), 2) intermittent exercise at 50% $\dot{V}O_{2max}$ for 60min (30-s intervals of exercise and rest; 30-s condition), and 3) intermittent exercise at 50% $\dot{V}O_{2max}$ for 60min (3-min intervals of exercise and rest; 3-min condition) at an ambient temperature of 25°C and a relative humidity of 50%. In each experiment, heart rate (HR), esophageal temperature (Tes), skin temperature (chest, upper arm, forearm, thigh and lower leg), sweating rate (chest and forearm, SR), skin blood flow (chest and forearm, SkBF), total sweating loss (TSL) and oxygen uptake ($\dot{V}O_2$) were measured. HR, mean skin temperature and mean body temperature were significantly lower during the two intermittent conditions than continuous condition. Although there is no significant difference in Tes among three conditions, changes in SkBF, SR, TSL and $\dot{V}O_2$ were significantly smaller during the two intermittent conditions than the continuous condition. In addition, there are not a marked differences in these variables between 30sec- and 3min conditions. Thus, there were no significant differences in Tes among three conditions even $\dot{V}O_2$ during continuous condition was significantly greater than the two intermittent conditions. It is suggested that this is due to greater heat dissipation associated with higher skin blood flow and sweating rate during continuous condition than intermittent conditions. In addition, a significant difference in Tb indicates that heat storage in intermittent conditions is lower than that in continuous condition at medium exercise intensity.

中強度の長時間間欠運動時における体温調節特性

林　建
神戸大学大学院人間発達環境学研究科

発表要旨

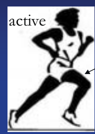
中強度間欠運動時における体温調節反応の特性を検討するために，同じ運動強度の継続運動時と比較した．10 名健康な男子大学生は室温 25℃，相対湿度 50%の環境下において 50%VO2max の継続運動（continuous）を 30 分間，同じ運動強度の間欠運動（30s 運動+30s 休息，30sec および 180s 運動+180s 休息，3min）を 60 分間実施した．測定項目は心拍数（HR)，食道温（Tes)，皮膚温（胸，上腕，前腕，大腿および下腿)，発汗量（胸および前腕，SR)，皮膚血流量（胸および前腕，SkBF)，総体重減少量（TSL）および酸素摂取量（$\dot{V}O_2$）とした．条件間の Tes に有意な差はみられなかったが，30sec および 3min 条件の HR，平均皮膚温（Tsk）および Tb は continuous 条件と比較して有意に低値を示した．また，SkBF，SR，TSL および $\dot{V}O_2$ は continuous 条件より 30sec および 3min 条件で有意に低くなったが，30sec と 3min 条件間に有意な差はみられなかった．これらのことから，Tes の変化は条件間で差がないが，Tb に差があり，これは間欠運動時の熱産生量は継続運動時のそれより少なく，これに関連して蓄熱量も小さいことが考えられる．

Thermoregulatory responses during prolonged intermittent exercise at medium intensity

Jian Lin
Graduate School of Human Development and Environment , Kobe University

Introduction

- Thermoregulatory responses during exercise



Heat production in the active muscles → No heat loss → Can't maintain exercise
Heat production in the active muscles → Heat loss → Can maintain exercise

- Earlier studies in thermoregulatory responses during exercise

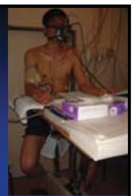
continuous : most
intermittent
- high intensity : a few
- medium intensity: none

High intensity intermittent exercise

References	Conditions		Intensity	Core temperature
Åstrand et al. (1960)	continuous		176W	↑
	Inter-mittent	30sec	352W	↑↑
		1min	352W	↑↑
		2min	352W	↑↑
		3min	352W	↑↑↑
Ekblom et al. (1971)	continuous		60%VO_2	↑
	30sec		120%VO_2	↑↑

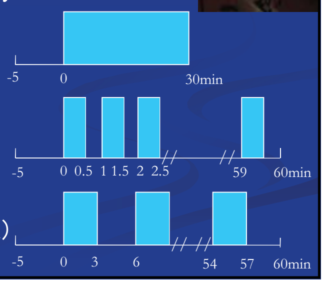
- **Purpose**: we have investigated the thermoregulatory responses during medium intensity continuous and intermittent exercise at same total workload, if we could see the same results during medium intensity as well as higher exercise intensity.

Methods



- Subjects: ten males
  (Age: 22.9±1.4years, Body mass: 62.8±2.7kg, Height: 171.2±2.4cm, VO_{2max}:54.7±2.3ml /kg/min)
- Experimental conditions
  25°C and 50% relative humidity
- Protocol

1) 50%VO_{2max} continuous exercise (continuous)
2) 50%VO_{2max} Intermittent exercise (30sE: 30sR, 30sec)
3) 50%VO_{2max} Intermittent exercise (180sE: 180sR, 3min)



- **Measurements**:

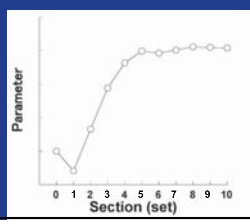
○ Heart rate (HR), Blood Pressure (BP) and Oxygen uptake (VO_2)

○ Esophageal temperature (Tes), Skin temperature (chest, upper arm, forearm, thigh and calf, Tsk)
Mean body temperature (Tb)=0.9 * Tes+0.1 * Tsk

○ Sweating rate (chest and forearm, SR), Skin blood flow (chest and forearm, SkBF), and Total sweat loss (TSL)
Cutaneous vascular conductance (CVC)= SkBF/MAP

Data analyses

	Continuous	Intermittent (30sec, 3min)
Exercise period:	30min	60min
Data analyses:	3min per	6min per



Results 1

＊:significantly different between con and 30sec

† :significantly different between con and 3min

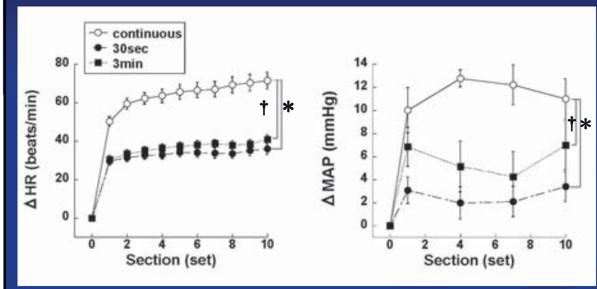


Fig.1

Results 2

＊:significantly different between con and 30sec

† :significantly different between con and 3min

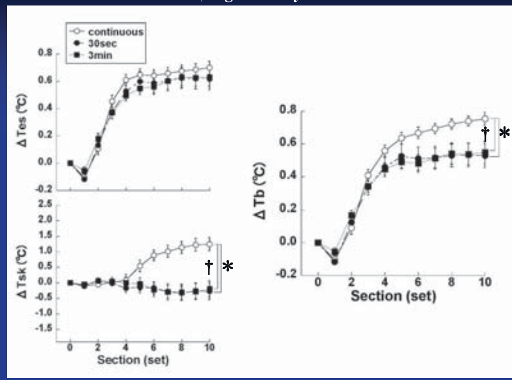


Fig.2

Results 3

＊:significantly different between con and 30sec

† :significantly different between con and 3min

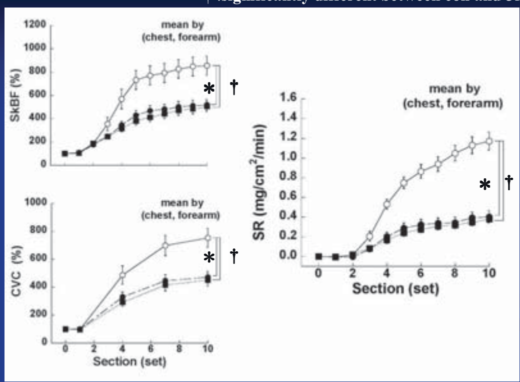


Fig.3

Results 4

＊:significantly different between con and 30sec

† :significantly different between con and 3min

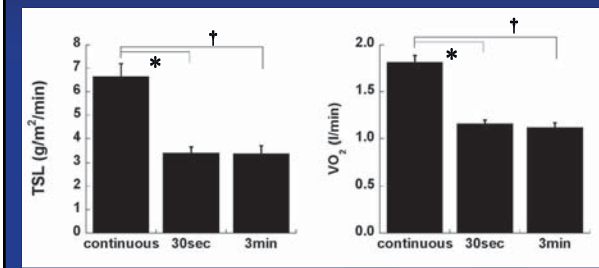


Fig.4

Discussion and conclusion

1) No difference in Tes among three conditions, even VO_2 during continuous condition was significantly greater than the two intermittent conditions.

- Due to greater heat dissipation associated with higher skin blood flow and sweating rate during continuous condition than intermittent conditions.
- this result is different from earlier studies in which change in core temperature during intermittent exercise was greater than continuous exercise. This was caused by different exercise intensity between earlier studies and this study.

2) Significant increase in Tb during continuous condition.

- indicating that heat storage during continuous exercise was greater than that during two intermittent exercises at medium exercise intensity.
- due to higher Tsk during continuous condition than two intermittent conditions.

Thank you for your attention!

The heat loss responses to isometric exercise under mildly hyperthermic condition in sprinters and distance runners.

Tatsuro AMANO
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ABSTRACT

To clarify the distinction of heat loss responses to a sustained handgrip exercise (non-thermal factors) between sprinters and distance runners, we compared the sweating response and skin blood flow responses during isometric handgrip exercise in the two groups under mildly hyperthermic conditions. Eight men sprinters and seven men distance runners performed isometric handgrip exercise at 20, 35 and 50% maximal voluntary contraction (MVC) for 60s after supine rest for 50min in a climatic chamber with a regulated ambient temperature of 35℃ and relative humidity of 50% to induce sweating response at rest by rising skin temperature without a marked change in internal temperature. Sublingual and mean skin temperatures (thermal factors) in both sprinters and distance runners groups were essentially constant throughout all exercise intensities. Changes in heart rate, mean arterial blood pressure and rating of perceived exertion with increased exercise intensity were similar in both groups. Responses of sweating rate and cutaneous vascular conductance on the chest, forearm, thigh and palm at each exercise intensities were not significantly different between sprinters and distance runners. Our results suggest that the physical trainings in sprinters and distance runners have similar effects on the sweating response and skin blood flow responses caused by non-thermal factors. However, there is a remain possibility that the heat loss responses caused by non-thermal factors may differ between sprinters and distance runners because the earlier studies indicated that cardiovascular responses was different between two groups during exercise for more than 2min.

短距離選手と長距離選手における静的運動時の熱放散反応特性

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発表要旨

短距離選手と長距離選手において静的運動を行った時の両者の熱放散反応(非温熱性要因)の違いを明らかにするために，暑熱環境下において静的掌握運動を行った時の両群の発汗反応と皮膚血流反応を比較した．男性短距離選手 8 名および男性長距離選手 7 名が 60 秒間の静的掌握運動を最大随意筋力(MVC)の 20%，35%および 50%の強度で行った．安静状態で皮膚温を上昇させ，深部体温を変化させることなく発汗を引き起こすために環境温 35℃，相対湿度 50%に設定した人工気象室内で実験を行った．すべての運動強度を通して短距離選手と長距離選手両群の舌下温および平均皮膚温(温熱性要因)はほぼ一定であった．

心拍数，平均血圧および自覚的運動強度は運動強度とともに増加し，その変化は両群でほぼ同じだった．すべての運動強度において両群の胸，前腕，大腿および手掌の発汗量及び皮膚血管コンダクタンスの応答に違いはなかった．これらの結果は，短距離選手と長距離選手の運動トレーニングが非温熱性要因による発汗反応および皮膚血流反応に与える影響は同じであることを示している．しかし，両群の心臓血管系応答に違いを引き起こすため, 2 分間以上の静的運動を行った時の非温熱性要因による熱放散反応は両群間で異なるかもしれない.

The heat loss responses to isometric exercise under mildly hyperthermic conditions in sprinters and distance runners

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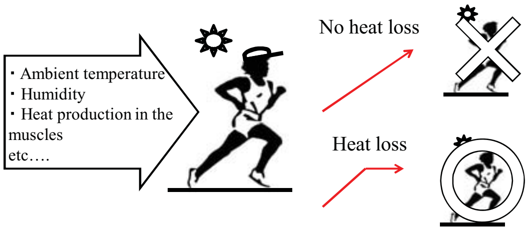
Introduction



Body temperature during exercise is controlled by two ways. One is behavioral temperature regulation, for example, we wear a cap and get out of clothes when ambient temperature is high. Another is autonomic temperature regulation such as sweating and skin vasodilation.

Autonomic temperature regulation

Thermal factors
- Body temperature
- Skin temperature

Non-thermal factors
- Central command
- Muscle mechanoreceptors
- Muscle metaboreceptors
- Baroreceptors
- Osmoreceptors etc..

→ **Thermoregulatory center** → **The heat loss**: **Sweating rate**, **Skin Vasodilation**

Earlier studies reported that physical trainings such as endurance training improve the heat loss responses in humans.

Previous studies

Table 1 The heat loss responses caused by thermal factors

Authors	Experimental conditions	Heat loss responses
Michael et al. (1977)	Training program	**Thresholds shifted to lower body temperature** (Skin vasodilation and sweating)
Baum et al. (1976)	Psssive heating	**Sweating threshold** Untrained > Distance runners
Irion (1987)	Bicycle ergometer	**Sweating rate** Distance runners > Sprinters
The heat loss responses caused by non-thermal factors		
Yanagimoto et al. (2002)	Isometoric handgrip exercise	**Sweating rate** Distance runners > Untrained

Thus, there are many studies that showed difference in the heat loss responses caused by thermal factors between different physical training groups, however, there is no study that investigates difference caused by non-thermal factors between these groups.

There are many studies that reported different cardiovascular responses to isometric handgrip exercise between different physical training groups.

Table 2

Torok et al. (1995)	3 min	**Mean arterial blood pressure (MAP) and heart rate (HR)** Sprinters > Distance runners
Sadamoto et al. (1992)	2 min	A close correlation between MAP and percentage of first-twitch (%FT) muscle fibers

Hypothesis

There is a possibility that the heat loss responses caused by non-thermal factors with isometoric exercise are different between sprinters and distance runners.

Purpose

To investigate the heat loss responses caused by non-thermal factors in sprinters and distance runners

Methods

○ **Subjects** : 17 males
(9 sprinters and 8 distance runners)

○ **Experimental conditions**
35℃ and relative humidity of 50%
→Inducing swearing even at rest without a marked body temperature change.

○ **Protocol**

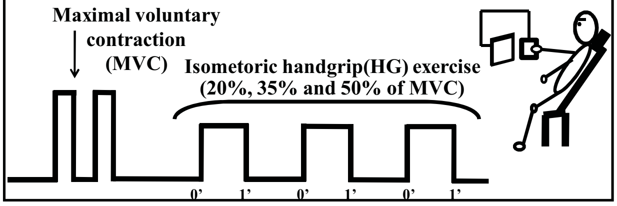


Table 3 Characteristic of two groups

	Distance	Sprinters
Age (yr)	20.4 ±0.7	20.5 ±0.3
Height (cm)	172.1 ±2.0	172.3 ±2.1
Weight (kg)	58.1 ±1.8	61.6 ±1.3
MVC (kg)	24.6 ±1.9	24.1 ±1.5
$\dot{V}O_{2max}$ (ml/kg/min)	53.9 ±1.4	46.1 ±1.5*

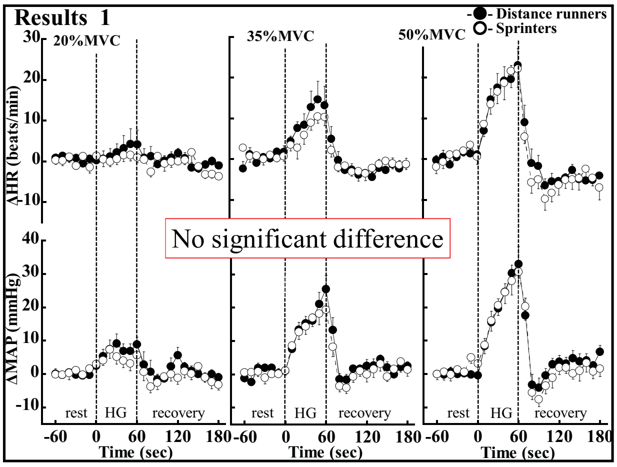
Values are mean ±SE. *: $P < 0.05$, compared with the distance runners

Measurements

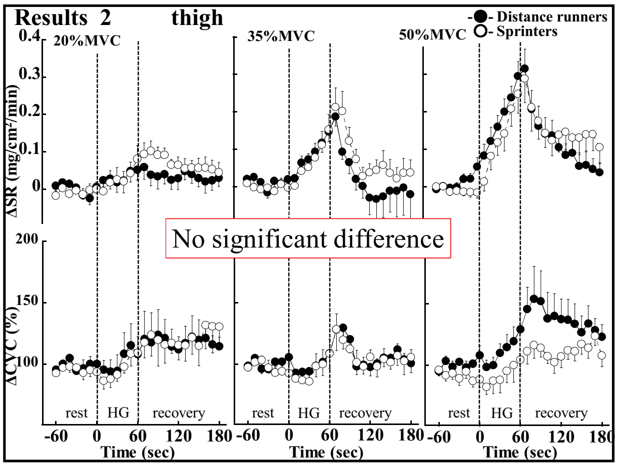
Cardiovascular parameters
Heart rate, Blood pressures, Stroke volume, Cardiac output and Rating of perceived exertion (RPE)

Thermoregulatory parameters
Oral temperature (Tor), Skin temperatures (forehead, chest, upper arm, forearm, thigh, leg and palm),
Sweating rate (SR : chest, forearm, thigh and palm),
Skin Blood flow (SkBF : chest, forearm, thigh and palm),
Cutaneous vascular conductance (CVC=SkBF / MAP)
and Active sweat glands

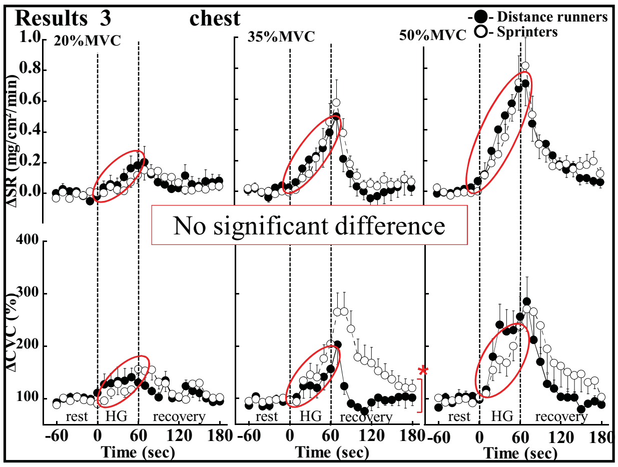
Results 1



Results 2 thigh



Results 3 chest



Main results and discussions

○ Responses of HR, MAP, SR and CVC at each exercise intensities are not different between sprinters and distance runners.

◆ The change in MAP does not agree with the earlier studies that showed significant difference between the two groups. There may be two reasons why the result in this study is different with the earlier studies.

② **Difference in degree of %FT in muscle** → The earlier studies reported a close relationship between MAP and %FT muscles during HG exercise (Sadamoto, 1992). In this study, MAP is similar between sprinters and distance runners throughout the experiment, so it could expect that % FT in muscle does not markedly differ between two groups.

◆ The results of SR and CVC
The changes in SR and CVC during each exercise intensities are similar between sprinters and distance runners. This may be because changes in HR and MAP were similar between two groups. The load of the exercise is too low to induce difference in heat loss response between two groups. There may be difference in heat loss responses if the changes of HR and MAP were different between two groups.

The effect of a dual task on step reaction to a soft surface ground in older adults

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Abstract

The ability to maintain postural stability is a basic requirement for determinants of daily activity for older adults with independence, but there are a number of complicated environments to survive in real life and then falls are frequent. To avoid falling, a rapid step is a very important protective strategy to recovery balance and it can contribute to age-related changes in postural stability. To stabilize human posture, the somatosensory is very important for controlling posture stability, but changes in mechanical properties of the skin and its receptors with age reduce the afferent information from the bottoms of the feet for their posture control. Meanwhile, older adults may have difficulty in moving and controlling posture while concurrently performing some tasks.

The purpose of this study was to investigate the effect of dual task on step reaction to soft surface ground which could cause less afferent information from the bottom of feet for older females. Nine young and eleven older females participated in this study. There were two task conditions: stepping while grasping an empty cup (single task) and stepping while grasping a cup filled with water (dual task). In both the tasks they had to land on a low-resistant mattress placed in front of them. The results revealed that step velocities for both ages were significantly slower in dual task than in single task. An interested finding was that the initiation time of stepping reaction in dual task was significantly longer for the older subjects than in single task. Furthermore %DSP (duration of swing phase as the percentage of a total stepping reaction time) was significantly lower and %DDP (duration of double-stance phase as the percentage of a total stepping reaction time) was significantly higher for the older than for the young females in both the tasks. These results suggested that a soft surface caused balancing difficulty and could adversely affect the step performance for the older females in dual task resulted by increasing the burden on the central nerve system.

高齢者の二重課題が柔らかい床面へのステップ反応に及ぼす影響

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神戸大学大学院人間発達環境学研究科

発表要旨

高齢者が自立した快活な生活を送るためには姿勢を安定して保持することが必要である．しかし日常の生活は多くの複雑な環境に囲まれており，高齢者の転倒の発生の頻度は高くなる．転倒防止のためには，最初の素早い防御ステップ反応が重要であることが知られているが，高齢者はこの防御的ステップ反応が遅延するといわれている．また姿勢調整のためには足底からの体性感覚情報が必要であるが，加齢に伴い皮膚やその受容器の機械的特性が変化するために足底からの求心性情報が減少する．一方で高齢者は様々なことを同時に行うための姿勢調整が困難であることも指摘されている．

本研究では，柔らかいマット上にステップすることで足底からの求心性情報を減少することが二重課題のパフォーマンスにどのように影響するか検討した．対象者は健常女性成人 9 名（平均 19.0 歳）と，健常高齢女性 11 名 (平 均 69.0 歳）であった．ステップ反応は①空のコップを持つ，②全量の水が入ったコップを持つ（二重課題）の 2 条件下で，対象者は目の前に置かれた低反発マット上でステップ動作を行った．結果は，両対象者において二重課題のステップ速度が単一課題よりも遅くなった．興味深いことは，高齢者の二重課題における初動時間が単一課題よりも延長したことである．さらに両課題において，高齢者の%DSP（全ステップ反応時間に対する遊脚期時間のパーセンテージ）が若年者に比べて低く，%DDP（全ステップ反応時間に対する両脚支持期時間のパーセンテージ）が高かった．これらのことから，高齢女性は柔らかい地面上でバランスをとることは困難であり．さらに二重課題を行うことで中枢の情報処理の負担が増えるためにステップパフォーマンスに影響を与えることが推察された．

The effect of a dual task on step reaction to a soft surface ground in older adults

Graduate School of
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Nobuko Harada, MA

Background

The delay of step reaction

The difficulty with a dual task

A lack of sensory information from the bottom of feet

Previous studies about compensatory step reaction

Researcher	Method	Results
McIlroy (1996)	Unpredictable perturbations	The older adults take additional steps , which were directed so as to preserve lateral stability.
Luchies (1994)	Pulled backward	The older adults often used multiple steps to regain balance.
Wojcik (1999)	Released from forward leans	The older female were not able to take a single rapid step because of the delay in response onset in older.

Previous studi

Researcher	Metho	
McIlroy (1996)	Unpredictable perturbations	The older adults take additional steps , which were directed so as to preserve lateral stability.
Luchies (1994)	Pu	The older adults often used multiple steps to regain balance.
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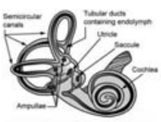
Older adults take multiple steps or a single step in order to regain their balance.

Older adults delay the initiating time in step reaction and the delay in response may be related to reduction of peripheral sensory inputs.

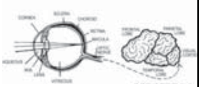
Three Important sensory inputs to control posture

1. Vestibular system



2. somatosensory

3. visual system



Previous studies found that

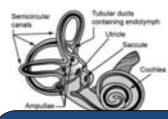
- Meissner's corpuscles become sparse and irregular with increasing age. (Bolton 1965)
- Tactile and vibratory sensitivity decrease in age at the foot than at the hand site of older adults. (Kenshalo 1986)

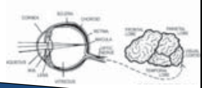
Three Important sensory inputs to control posture

1. Vestibular system

2. somatosensory

3. visual system





The mechanical properties of skin and its receptors change with age and reduce the afferent sensory information from the bottom of feet.

- Tactile and vibratory sensitivity decrease in age at the foot than at the hand site of older adults. (Kenshalo 1986)

Previous studies about the effect of a dual task

Primary Task	Researcher	Secondly Task	Results of studies
standing	Shumway-Cook (2000)	Auditory memory task	Posture sway was increased in older adults
	Melzer (2001)	stroop test	Posture sway was increased in older adults.
walking	Lundin-Olsson (1997)	talking	Identifying fall-prone people is tending to stop talking
	Toulotte (2006)	Grasping a cup filled with water	Gait parameters (e.g. speed, stride) were lower in the fallers
Voluntary stepping	Melzer (2007)	stroop test	Step reaction was prolonged in older adults.

Older adults are affected by a dual task but it is doubtful about the clear difference between older and young adults or fallers and non-fallers.

Few studies have examined the effect of a dual task in condition of the changes on somatosensory from the bottom of feet.

ies
vas increased
vas increased
Olsson (1997)
fall-prone people is tending to stop talking
Toulotte (2006) Grasping a cup filled with water Gait parameters (e.g. speed, stride) were lower in the
Voluntary stepping Melzer (2007)

Purpose

・Investigate the effect of a dual task on step reaction to a soft surface ground, which cause less somatosensory information from the bottom of feet.

We hypothesized that in a dual situation, older adults would have difficulty with controlling posture more than in a single task.

Method 1. subjects

・Eleven older healthy female

Age: 69.0±3.1 years old
Height: 151.9±3.9 cm
Weight: 51.3±6.3 kg

・Nine young healthy female

Age: 19.0±0.9 years old
Height: 157.4±4.8 cm
Weight: 52.1±6.1 kg

2. Experimental protocol

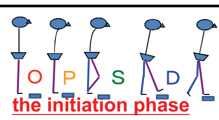
①Subjects were instructed to stand up right and barefoot on a force plate.

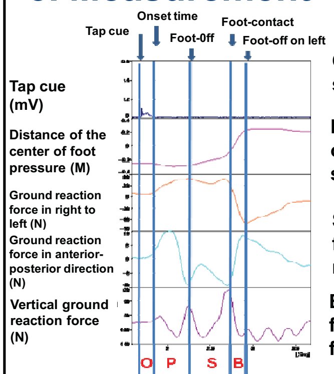
②They stepped forward as quickly as possible following tap cue on the back of heel, landed on a soft mattress, which caused less afferent information from the bottom of feet, placed toward and put their feet side by side.

③They grasped an empty cup as a single task and a cup with filled water as a dual task during stepping.

④They were instructed to focus on stepping as quickly as possible.

3. Measurement





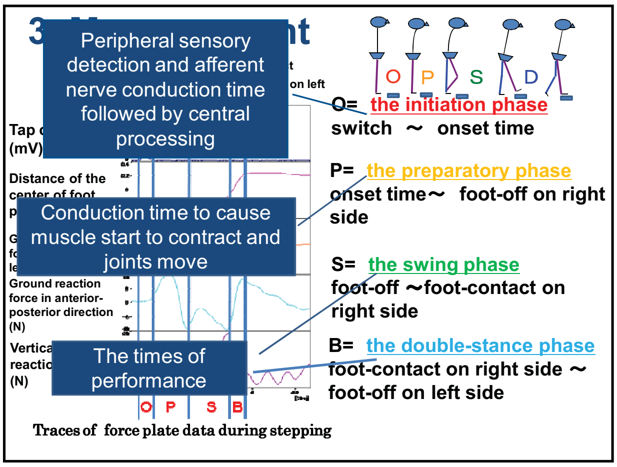
Traces of force plate data during stepping

O= the initiation phase
switch ～ onset time

P= the preparatory phase
onset time～ foot-off on right side

S= the swing phase
foot-off ～foot-contact on right side

B= the double-stance phase
foot-contact on right side ～ foot-off on left side



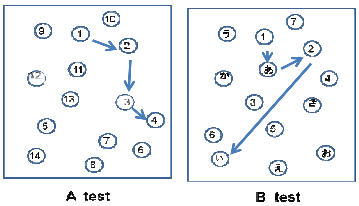
・total time of stepping(sec)： O+P+S+B

・step length (cm) ： L

・step velocity (cm/sec)： L / (O+P+S+B)

・each reaction phase as the percentage of a stride time(%)
: O, P, S, B / (O+P+S+B) ＊100

1. Trail Making Test A･B (TMT)



ΔTMT: TMT･A-TMT･B.
an assessment of capacities of a person's independence and self-serving behavior with attention.

2. Berg Balance Test

:including ability to sit, stand, reach, lean over, turn and look over each shoulder and step.

Result 1

Table 1. The result of relationship between ages for ΔTMT and BBT

	ΔTMT (sec)	BBT (point)
Older	75.0±46.2	54.8±1.4
Young	14.6±6.2	55.9±0.3

ΔTMT: ＊＊; BBT: ＊

＊:p<0.05
＊＊:p<0.01

The Older had difficulty with performing activity independently with attention compared to the young female.

The Older had difficulty with controlling balance compared to the young female .

	ΔTMT (sec)	BBT (point)
Older	75.0±46.2	54.8±1.4
Young	14.6±6.2	55.9±0.3

ΔTMT: ＊＊; BBT: ＊

＊:p<0.05
＊＊:p<0.01

Result 2

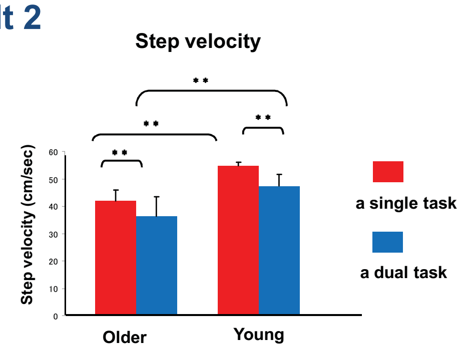


Fig 1. Average step velocity and standard deviations

＊:p<0.05
＊＊:p<0.01

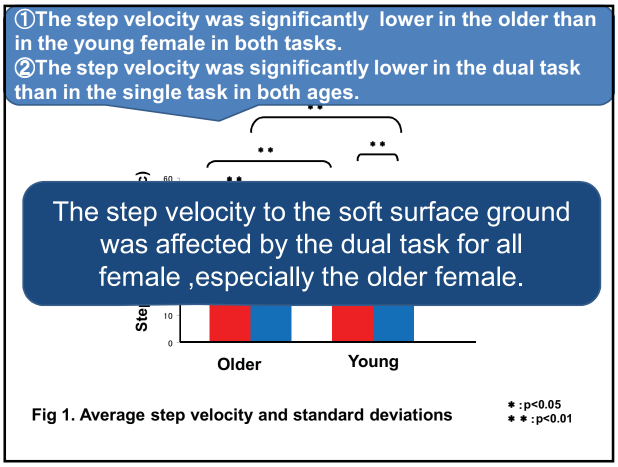


Fig 1. Average step velocity and standard deviations

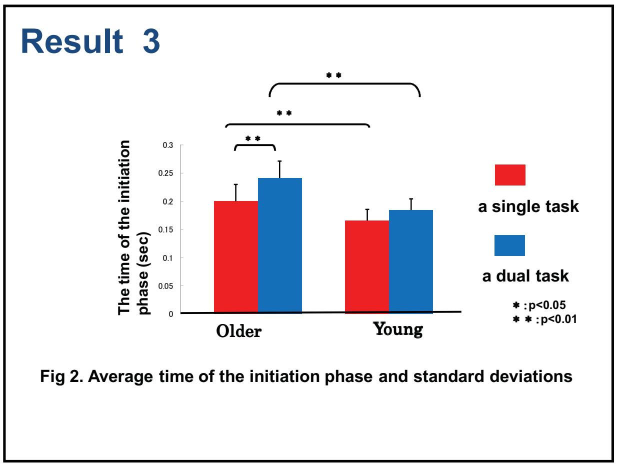


Fig 2. Average time of the initiation phase and standard deviations

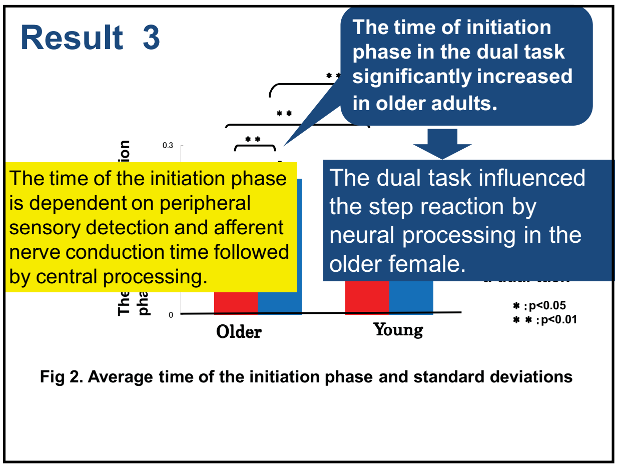


Fig 2. Average time of the initiation phase and standard deviations

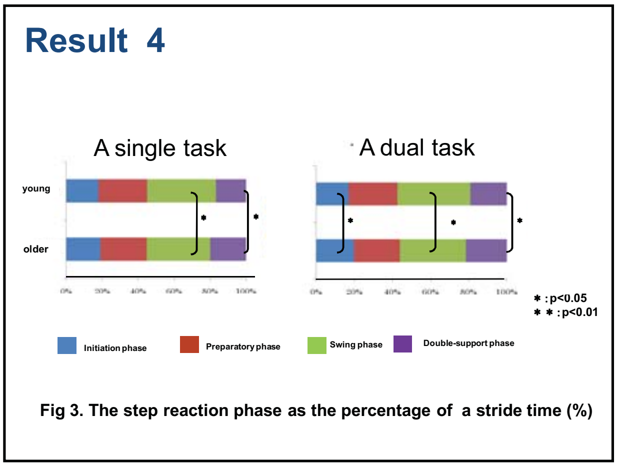


Fig 3. The step reaction phase as the percentage of a stride time (%)

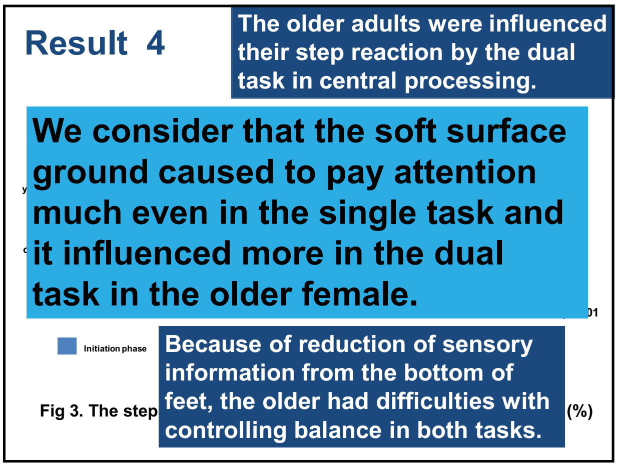


Fig 3. The step (%)

Conclusion

- The older female, who could have a decrease of sensory information from the bottom of feet, had difficulty with controlling posture so that they could have already allocated attentional demands before they started the step reaction against the soft surface ground.

- Adding another attentional demand could be adverse to effect the step reaction in the older female by increasing responsibility of central processing.