# Overgewicht, het gevolg van te weinig beweging of teveel eten?

**evidence from $^{2}H_{2}{}^{18}O$ studies**

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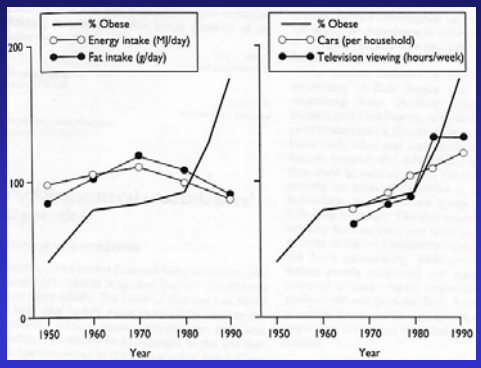
## Obesity through sloth?




Prentice and Jebb Br Med J 1995;311:437-9

## Synopsis

Physical activity of modern humans is in line wild terrestrial mammals

To prevent weight gain: reducing intake is more effective than increasing physical activity

## Outline

Physical activity assessment

Physical activity in modern man

Training effects

Food intake and physical activity

## Energy expenditure

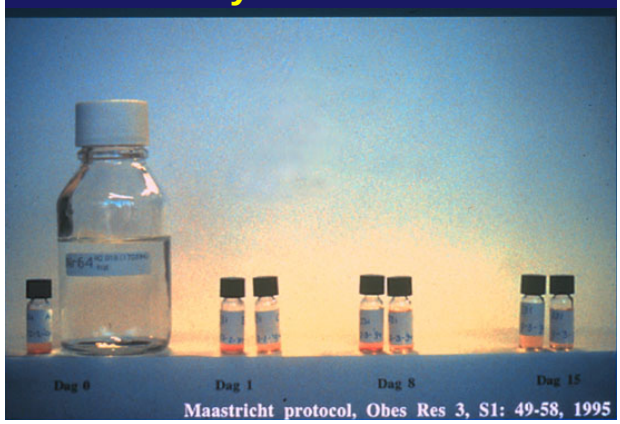
Indirect calorimetry: measurement of oxygen consumption and/or carbon dioxide production

Ventilated hood ->

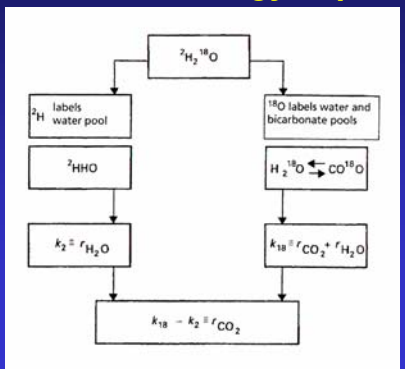
<-Respiration chamber

Doubly labeled water->

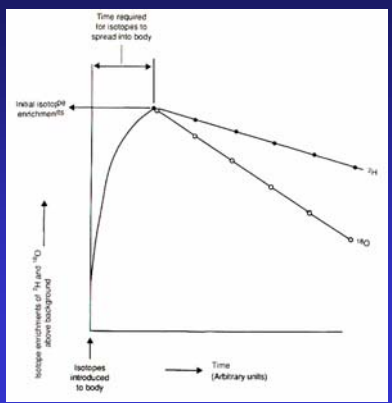
## Doubly labeled water



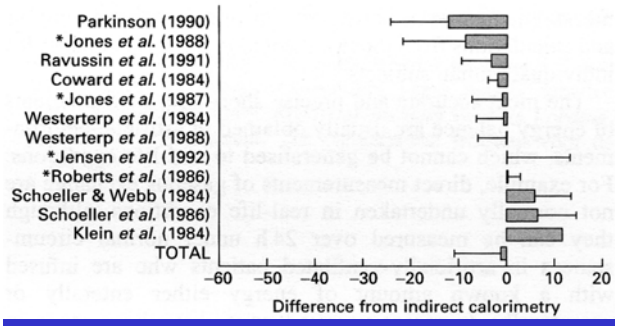

## Principle of $^{2}H_{2}{}^{18}O$ method for measurement of energy expenditure




## Elimination curves $^{2}H$ and $^{18}O$

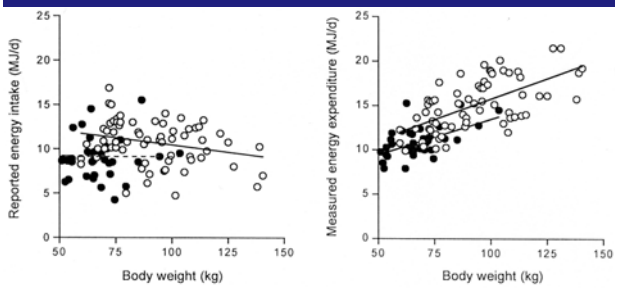


## Validation results $^{2}H_{2}{}^{18}O$



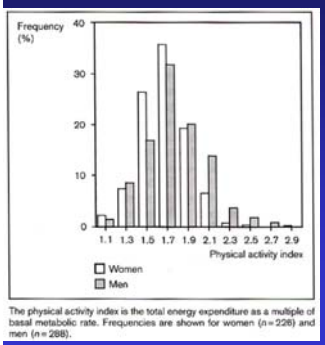

Non-significant difference with simultaneous chamber results

## Reported intake, measured expenditure and body weight




Westerterp Nutr Rev 2010;68:148-54

## AEE: most variable component




The physical activity index is the total energy expenditure as a multiple of basal metabolic rate. Frequencies are shown for women (n = 226) and men (n = 288).

Variation in AEE

PAL 1.2: AEE = 5%

PAL 2.5: AEE = 50%

Westerterp & Plasqui Curr Opin Clin Nutr Metab Care 2004;7:607-13

## Conclusions

Maintenance metabolism largest component

Activity energy expenditure most variable

Food intake measurement complicated by misreporting

## Physical activity in 'modern' man

Physical activity energy expenditure has not declined since the 1980s and matches energy expenditure of wild mammals

Westerterp et al. Int J Obes 2008;32:1256-63

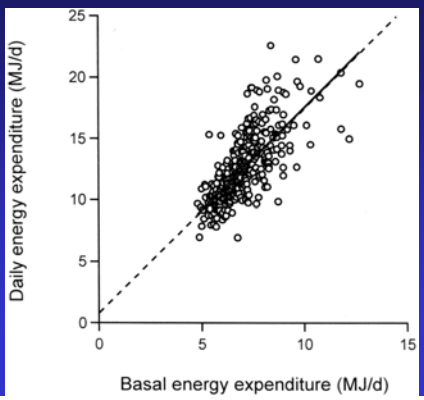
## Design

Assessment of activity energy expenditure with $^{2}H_{2}{}^{18}O$

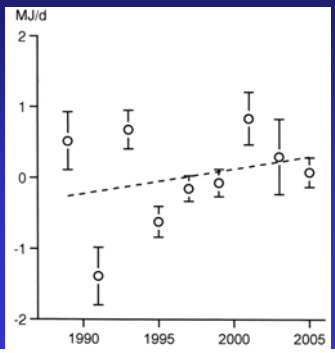
Time trend analysis since 1985

Comparison with wild mammals

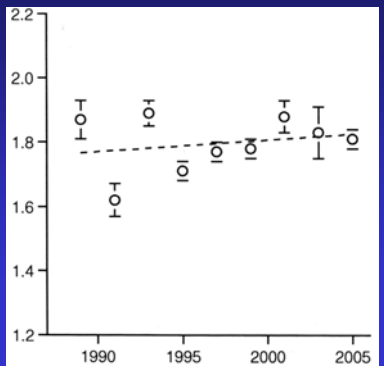
## Residual DEE-BEE



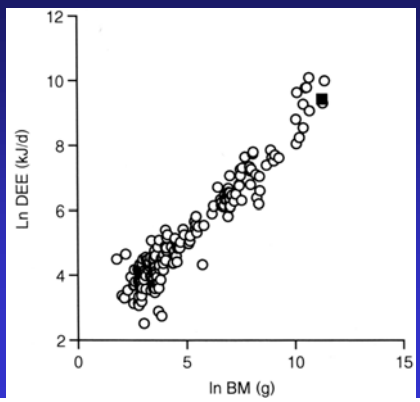

## Significant increase of the DEE-BEE residual in time



## No significant change in PAL over time




## Energy expenditure and weight




## Conclusions

There is no indication that energy expenditure on physical activity or total energy expenditure have declined over the past decades

Daily energy expenditure of modern humans is in line with the prediction from measurements of wild terrestrial mammals

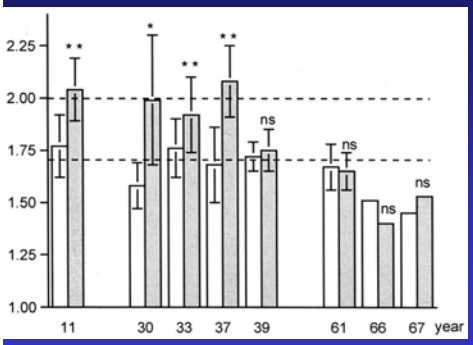
## Exercise training and AEE

| Training programme | *n* | Age (years) | BMI (kg/m$^2$) | $PAI_{before}$ | $PAI_{after}$ |
|---|---|---|---|---|---|
| 9 weeks of jogging for ⩽1 h/day | 5 | 30±3 | 22.4±2.2 | 1.58±0.11 | 1.99±0.31* |
| 4 weeks of cycling five times for 1h/day | 10 | 11±1 | 23.9±2.0 | 1.77±0.15 | 2.04±0.15** |
| 8 weeks of cycling three sessions per week | 11 | 66±6 | 24.5±2.6 | 1.51 | 1.40, NS |
| 40 weeks of jogging for up to 50 km/week | 13 | 37±3 | 22.5±1.6 | 1.68±0.18 | 2.08±0.17** |
| 8 weeks energy restriction, 4.5 h/week exercise training | 10 | 39±5 | 32.4±1.3 | 1.72±0.07 | 1.75±0.10, NS |
| 18 weeks of weight training for 2 h/week | 12 | 33±6 | 23.6±1.7 | 1.76±0.14 | 1.92±0.18** |
| 26 weeks of resistance training for 2.3 h/week | 15 | 67±4 | 24.8±3.9 | 1.45 | 1.53 |
| 12 weeks of resistance training for 2 h/week | 22 | 61±6 | 27.5±4.9 | 1.67±0.11 | 1.65±0.09, NS |

PAI, physical activity index. *$P$ <0.05; ** $P$ <0.01 for difference with before training programme.

Westerterp & Plasqui Curr Opin Clin Nutr Metab Care 2004;7:607-13

## Exercise training and AEE

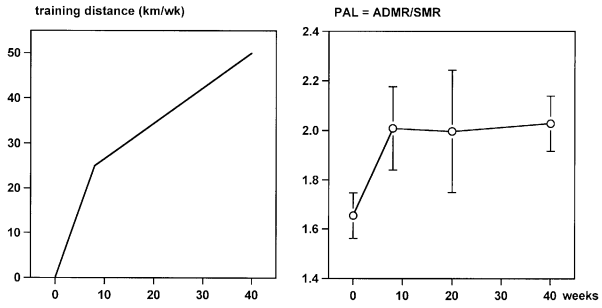



PAL before and after training

for different age groups

Westerterp & Plasqui Curr Opin Clin Nutr Metab Care 2004;7:607-13

## Exercise training and physical activity level




Westerterp et al. Br J Nutr 1992;68:21-30

## Conclusions

Exercise training can increase energy expenditure

The effect is a function of food intake and age

## Training and body weight

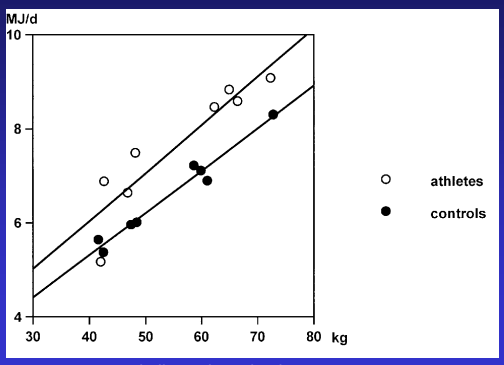
training induced changes in physical activity level and body mass

| | PAL before | PAL after | Δ body mass (kg) |
|---|---|---|---|
| jogging (40wk) | 1.68 | 2.13 ** | - 1.0 * |
| weight training (18wk) | 1.76 | 1.92 * | + 0.1 ns |
| cycling (4wk) | 1.77 | 2.04 * | + 0.5 ns |

ns non-significant, * p<0.01, ** p<0.001

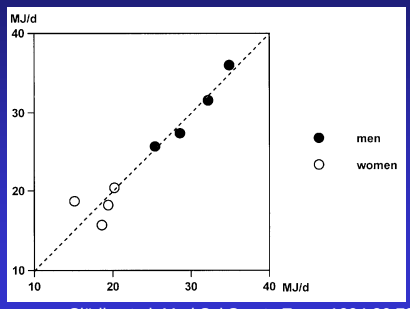
Adapted from Kempen et al., Am J Clin Nutr 1995;62:722-9

## Exercise, FFM and RMR



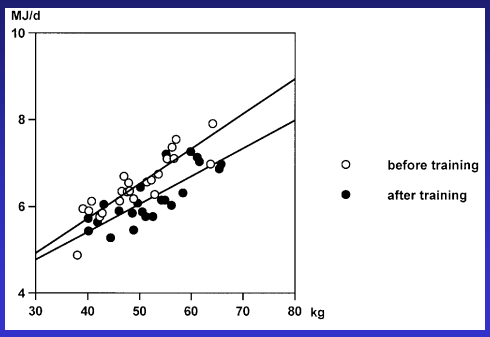

Sjödin et al. Med Sci Sports Exerc 1996;28:85-91

## Energy intake and -expenditure in elite athletes



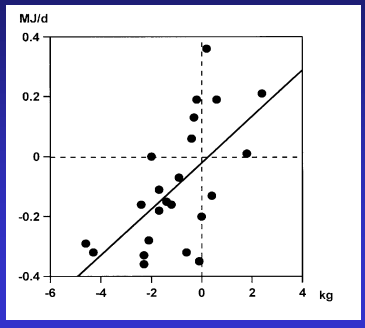

Sjödin et al. Med Sci Sports Exerc 1994;26:720-4

## Exercise, FFM and RMR in non-athletes




Westerterp et al. Eur J Appl Physiol 1994;69:203-8

## Training, body mass and SMR in non-athletes




Westerterp et al. Eur J Appl Physiol 1994;69:203-8

## Conclusions

Elite athletes have an increased FFM

Elite athles have an increased $FFM_{adj}$ RMR

Exercise induces a reduced RMR when BM is not maintained

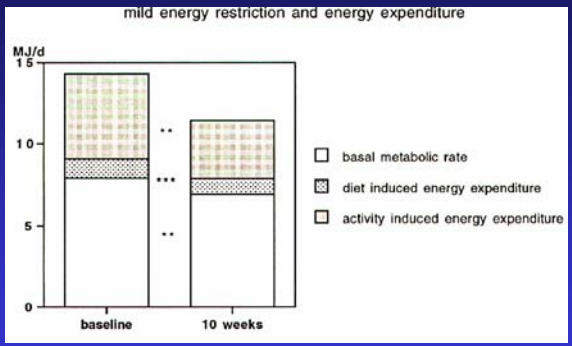
## Under-eating and AEE

**Energy saved by 24 weeks semi-starvation in the Minnesota Experiment**

| | (MJ/d) | (% of total) | |
|---|---|---|---|
| BMR | 2.6 | 32 | 65% for a decreased active-tissue mass<br>35% for a lowered tissue metabolism |
| DEE | 0.8 | 10 | |
| NEAT | 4.7 | 58 | 40% for a reduced body weight<br>60% for a reduced physical activity |
| Total | 8.0 | 100 | |

Main saving on energy expenditure from reduced AEE

## Under-eating and AEE




10 wk 33% reduction of baseline requirement

Velthuis-te Wierik et al. Int J Obes 1995;19:318-24

## Conclusions

A reduction in food intake decreases energy expenditure

Activity induced energy expenditure shows the largest decrease

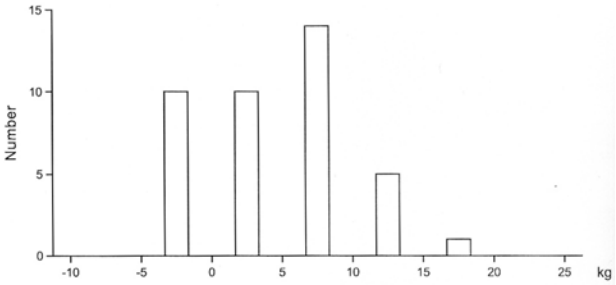
## Moving less

| | Baseline | Follow-up |
|---|---|---|
| Age (y) | 27±5 | 39±8*** |
| Body mass index (kg/m$^2$) | 22.8±2.0 | 24.3±2.6** |
| Resting energy expenditure (REE, MJ/d) | 6.76±0.98 | 6.84±1.00 |
| Toal energy expenditure (TEE, MJ/d) | 12.19±1.82 | 11.95±1.77 |
| Activity energy expenditure (0.9TEE-REE, MJ/d)[1)] | 4.21±1.05 | 3.92±1.19* |
| Physical activity level (TEE/REE) | 1.81±0.16 | 1.75±0.11** |

[1)]Calculation based on a fixed 10% of TEE for diet induced energy expenditure.
* P<0.05; ** P<0.01; *** P<0.001 for difference with baseline (n=40).

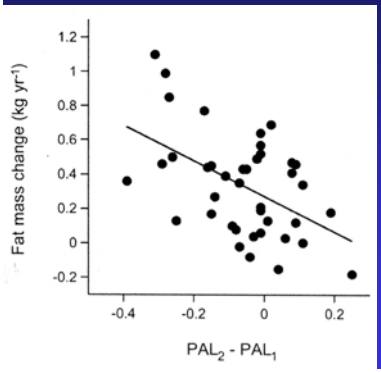
Westerterp and Plasqui PLoS ONE 2009;4:e4745

## Weight change over 12 year




Westerterp and Plasqui PLoS ONE 2009;4:e4745

## Moving less




Westerterp and Plasqui PLoS ONE 2009;4:e4745

## Conclusions

Eating more does not result in moving more
Eating less results in moving less

Moving more results in eating more
Moving less is not compensated by an equivalent intake reduction