

# Energy requirements of Indians

Anura Kurpad, MD, PhD, FRCP, FAMS

St John's Medical College

# Why?

- Individual health
- Public Health

Ludlow Jute Mill, Calcutta: studies on wide range of physical activity, from sedentary to very hard work

Article Navigation

**Relation between Caloric Intake, Body Weight, and Physical Work:  
STUDIES IN AN INDUSTRIAL MALE POPULATION IN WEST BENGAL**

JEAN MAYER, D.Sc, PURNIMA ROY, B.Sc, KAMAKHYA PRASAD MITRA, M.B., B.S.

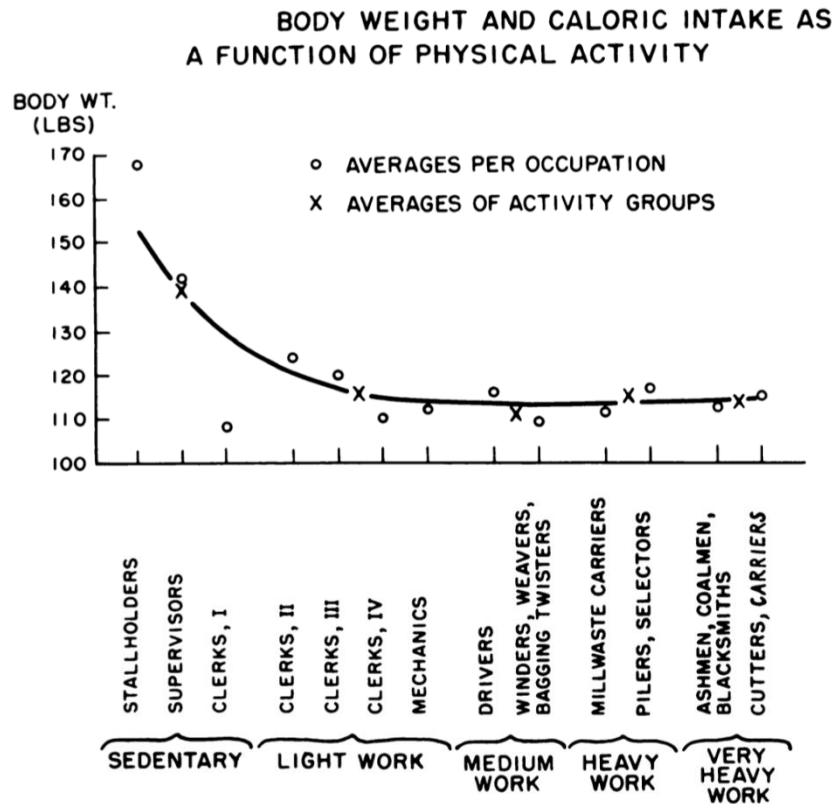


Figure 1

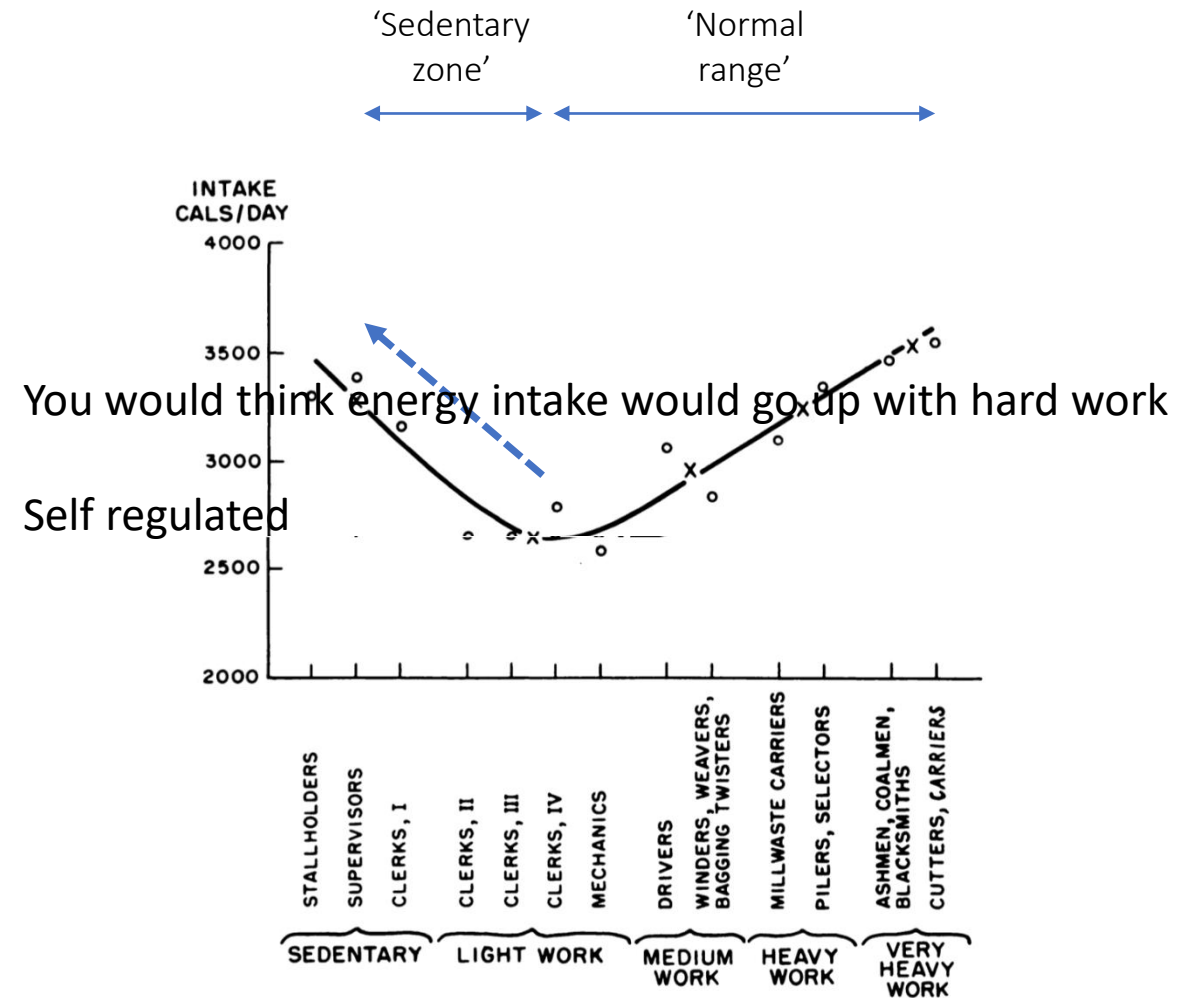
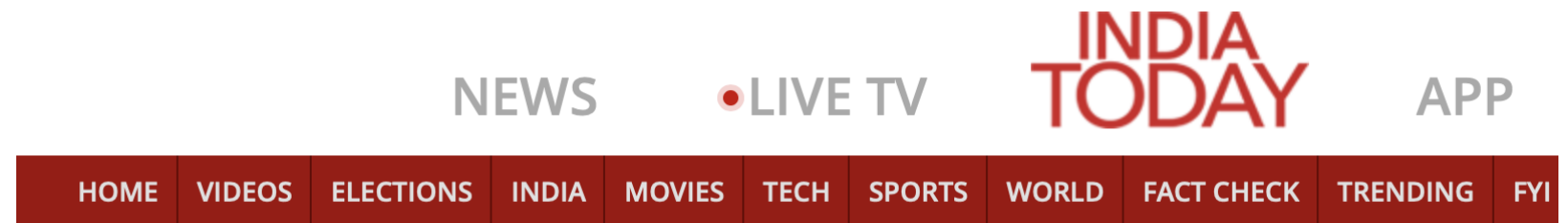


Figure 1

# SDG goal to have zero hunger

- Dependent on a *notional energy requirement*
- Quantum of food subsidy is energy and cereal centric
- Counter-intuitively: has potential for positive energy balance



News / India /

## **Do not give free rice in Tamil Nadu, people are becoming lazy: Madras High Court**

*The court said since rice is provided free to all, people have become lazy and we have to import workers from northern states even for menial works.*

## Poverty nutrition linkages

Prema Ramachandran

India was the first country in the world to define poverty as the total per capita expenditure of the lowest expenditure class, which consumed 2400 Kcal /day in rural and 2100 Kcal/day in urban areas and attempted to provide comprehensive package of essential goods and services to people below the poverty line.

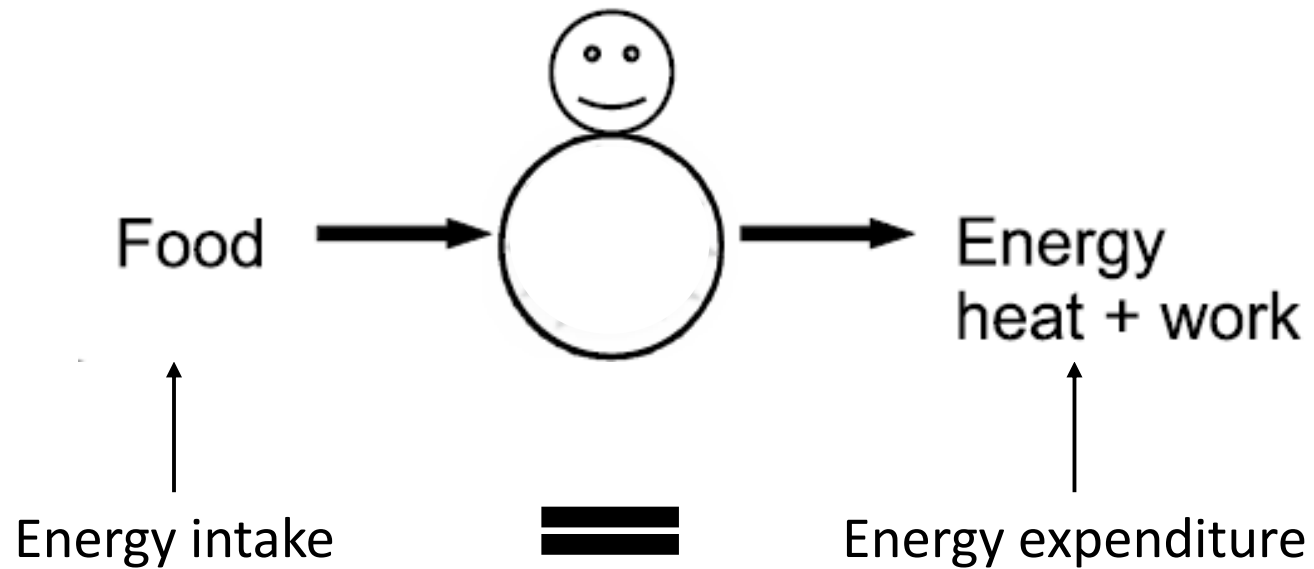
- Estimating the hungry in the BPL population
- Based on FAO norm – minimum dietary energy requirement
  - 1800 kCal/day
  - Based on weighted avg 5<sup>th</sup> percentile of BMI for attained height
  - Too low, and probably would not be sustainable
- Chand and Jurmani (2013) – used ICMR-2010 requirement and FAO – found that prevalence of undernourishment in BPL persons was 30% higher with ICMR norm, compared to FAO norm

# Computation of revised energy requirement – Rangarajan Committee

Age	Sex	Activity	Population weights(Rural)*	Population weights(Urban)*	Energy requirement (kcal) (ICMR)- 2010
less than 1			1.79	1.44	585
1 to 3			6.07	4.83	1060
4 to 6			6.7	5.19	1350
7 to 9			6.65	5.24	1690
10 to 12			7.33	5.85	2100
13 to 14	Male		2.22	1.92	2750
	Female		2.06	1.76	2330
15 to 59	Male	Sedentary	3.67	13.66	2320
		Moderate	12.78	9.03	2730
		Heavy	7.93	3.84	3490
		Non-worker	5.35	7.31	2320
15 to 59	Female	Sedentary	1.05	3.43	1900
		Moderate	5.45	1.64	2230
		Heavy	4.03	1.53	2850
		Non-worker	17.78	24.84	1900
60 & above#	Male		4.32	4	2320
	Female		4.47	4.11	1900
<b>Energy requirement (kcal)*</b>			<b>2155</b>	<b>2090</b>	

\*Planning commission, 2014. The population weights are based on the proportion of each population represented as the population structure in the 2011 Census of India separately for rural and urban sectors. This is specific to age, sex and occupation (used as a proxy for activity).

# Defining the Energy Requirement



- Based on Energy Expenditure (EE)
- Not Energy Intake (EI)



## Present energy requirement- ICMR-NIN 2010 (kCal/day)

<b>Man</b>	<b>60 Kg</b>	
Sedentary work	2320	
Moderate work	2730	+400
Heavy work	3490	+1150
<b>Woman</b>	<b>55 Kg</b>	
Sedentary work	1900	
Moderate work	2230	+330
Heavy work	2850	+950

# Boys – ICMR-NIN 2010

Age	Total Energy requirement		
	Sedentary	Moderate	Active
1-2		910	
2-3		1120	
3-4		1230	
4-5		1290	
5-6		1390	
6-7	1270	1510	1760
7-8	1340	1630	1850
8-9	1530	1750	2070
9-10	1610	1890	2180
10-11	1700	2030	2310
11-12	1920	2180	2550
12-13	2020	2370	2680
13-14	2160	2580	3010
14-15	2280	2760	3180
15-16	2530	2890	3310
16-17	2600	2980	3400
17-18	2660	3060	3490

# Defining the requirement

- Factorial method- measure each component of EE
- Total measurement of EE

# Predict from Components of Energy Expenditure

Physical Activity  
(PA)

Thermic Effects of Food  
(TEF, FIT)

Basal Metabolic Rate  
(BMR, REE)



Based on measurement  
Questionnaire

Based on prediction equations  
-weight, age and sex

# Measuring BMR

# BMR measurements are not trivial

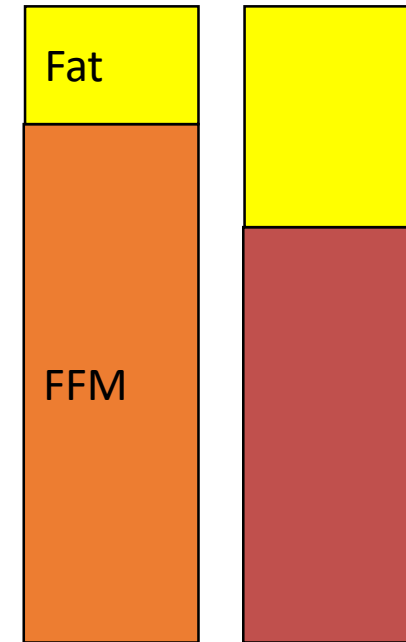
- Require a great deal of attention to detail
  - Soon after awakening
  - Fasting
  - Not sleeping
  - Thermoneutral
- 
- Many reports will show that measurements were actually RMR
    - May be about 10% higher than BMR

# At scale...

- BMR is usually predicted from age- sex-specific equations
- Most famous – Schofield or WHO equation
  - Many clinical equations - Harris-Benedict, Owen, Mifflin
- The equation depends on the population it was derived from
  - Muscular, active young men (army recruits) in the WHO data set would probably have a higher BMR

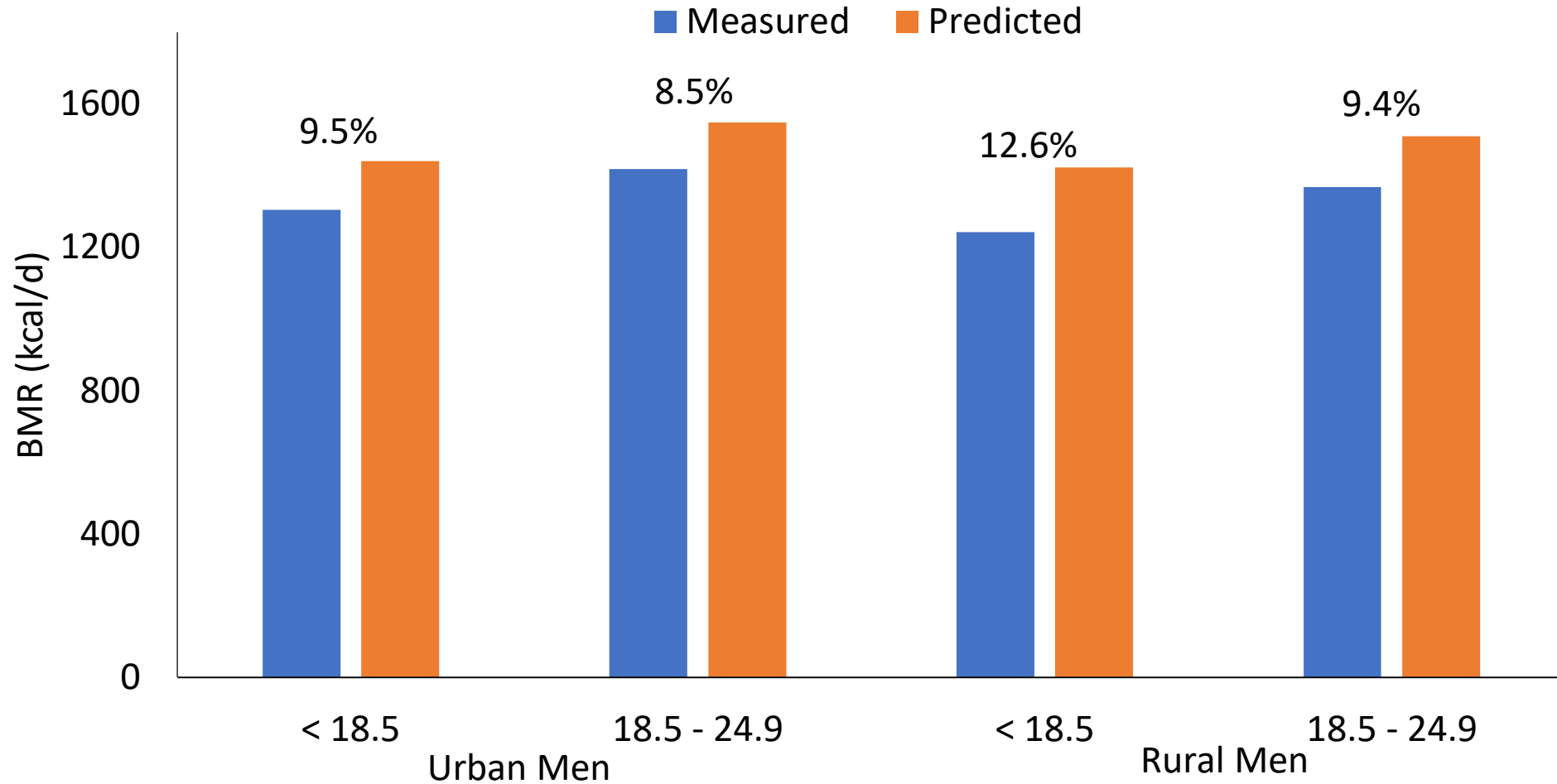
# Body composition & BMR Adaptation?

- 60 kg with 15% fat = 51 Kg FFM
- 60 kg with 30% fat = 42 Kg FFM
- 10 Kg difference in the active tissue
- Could account for about 250 Kcal/day
  - Or >10% of EE





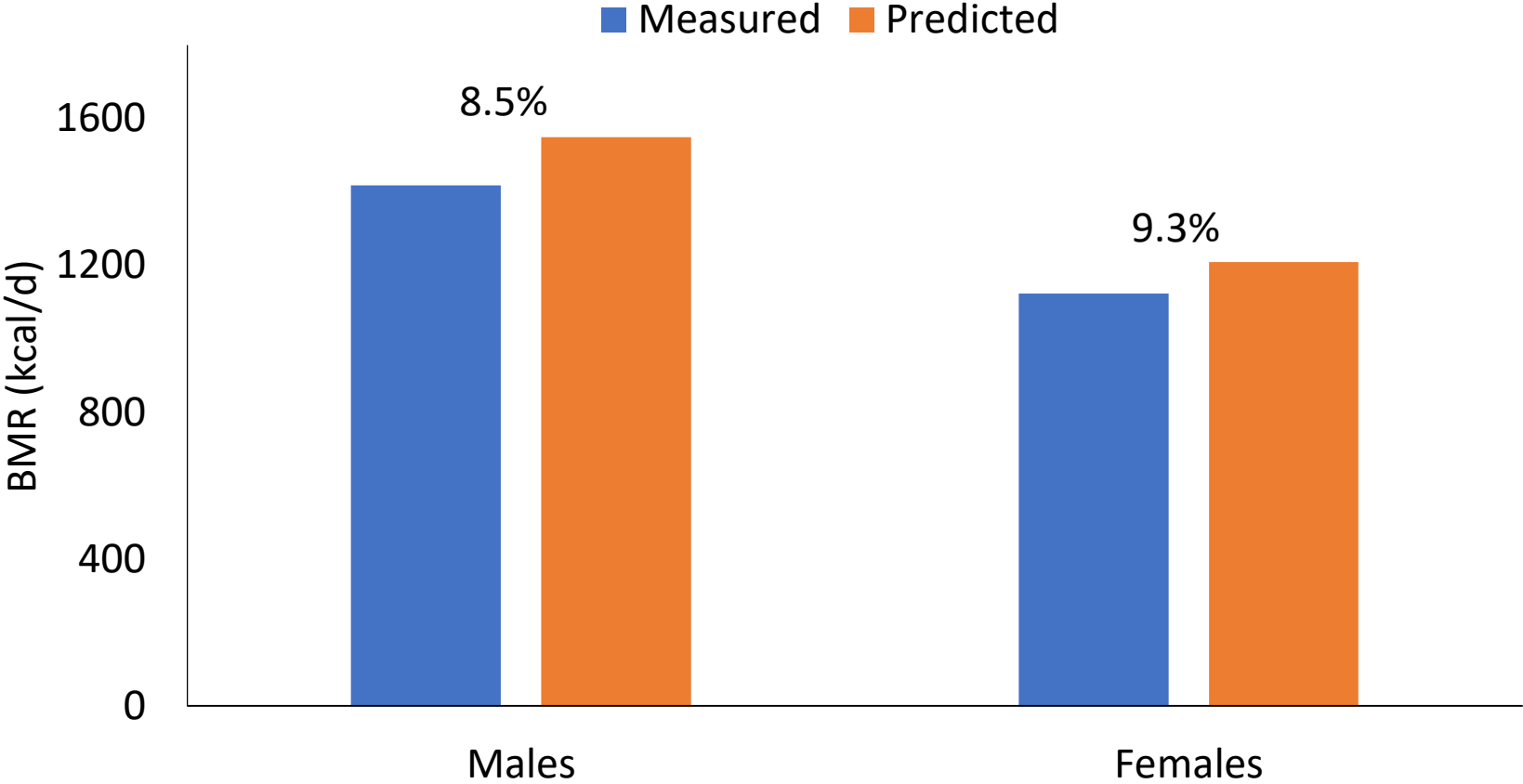
# Is BMR Over-estimated by prediction equations?



BMR predicted using Schofield's equation (FAO/WHO/UNU, 2004)

McNeill et al. 1987; Soares and Shetty, 1988; Soares et al. 1993

# Comparison of measured and predicted BMR for Indian men and women with normal BMI



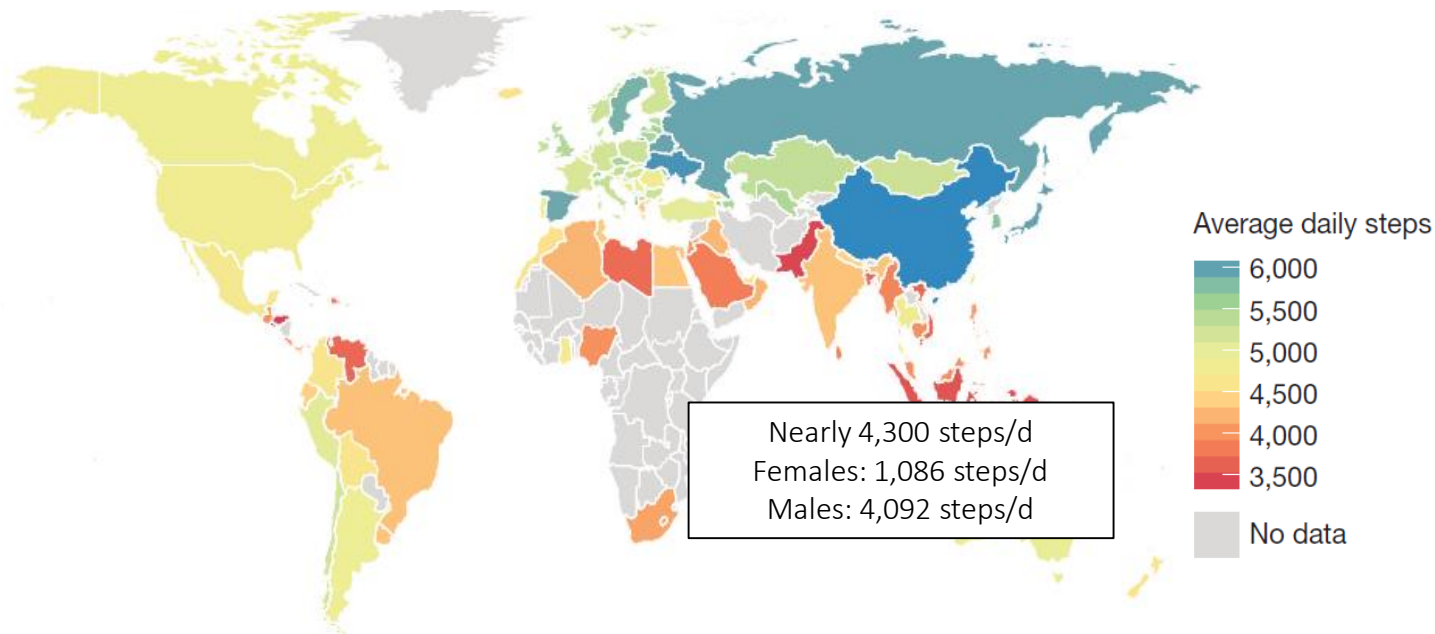
BMR predicted using Schofield's equation (FAO/WHO/UNU, 2004)  
Soares and Shetty, 1988; Soares et al. 1993; Piers and Shetty, 1993

Measuring the other component- activity

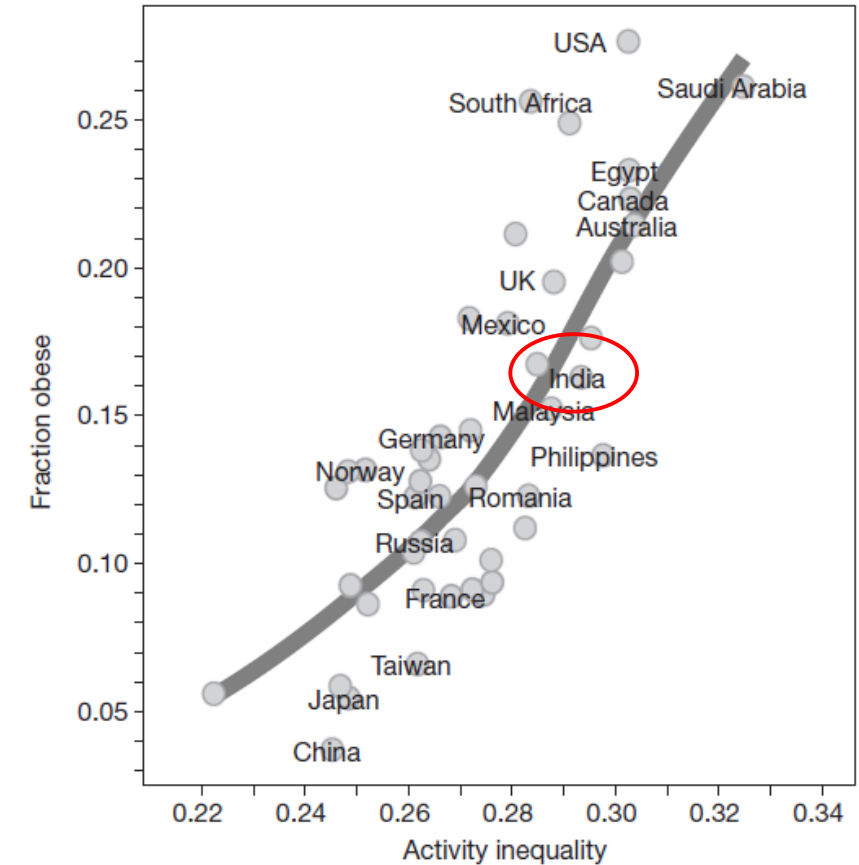
# Large-scale physical activity data reveal worldwide activity inequality

Tim Althoff<sup>1</sup>, Rok Sosič<sup>1</sup>, Jennifer L. Hicks<sup>2</sup>, Abby C. King<sup>3,4</sup>, Scott L. Delp<sup>2,5</sup> & Jure Leskovec<sup>1,6</sup>

Measured physical activity using app-based step counts from smartphones and self reported BMI (n=717,527)



- Indian ranked low in physical activity with large gender gap;
- A careful attention is required in defining energy requirement for sedentary population



- Activity inequality associated with obesity
- Higher the inequality higher the obesity

- Take a history of activity
- Multiply each activity duration into its activity expenditure (PAR)
- Sum
- Divide by the total number of minutes
- This gives a 'summed factor' that is multiplied into the BMR

# We take the PAR from books: Is energy cost for each activity for Indians low?

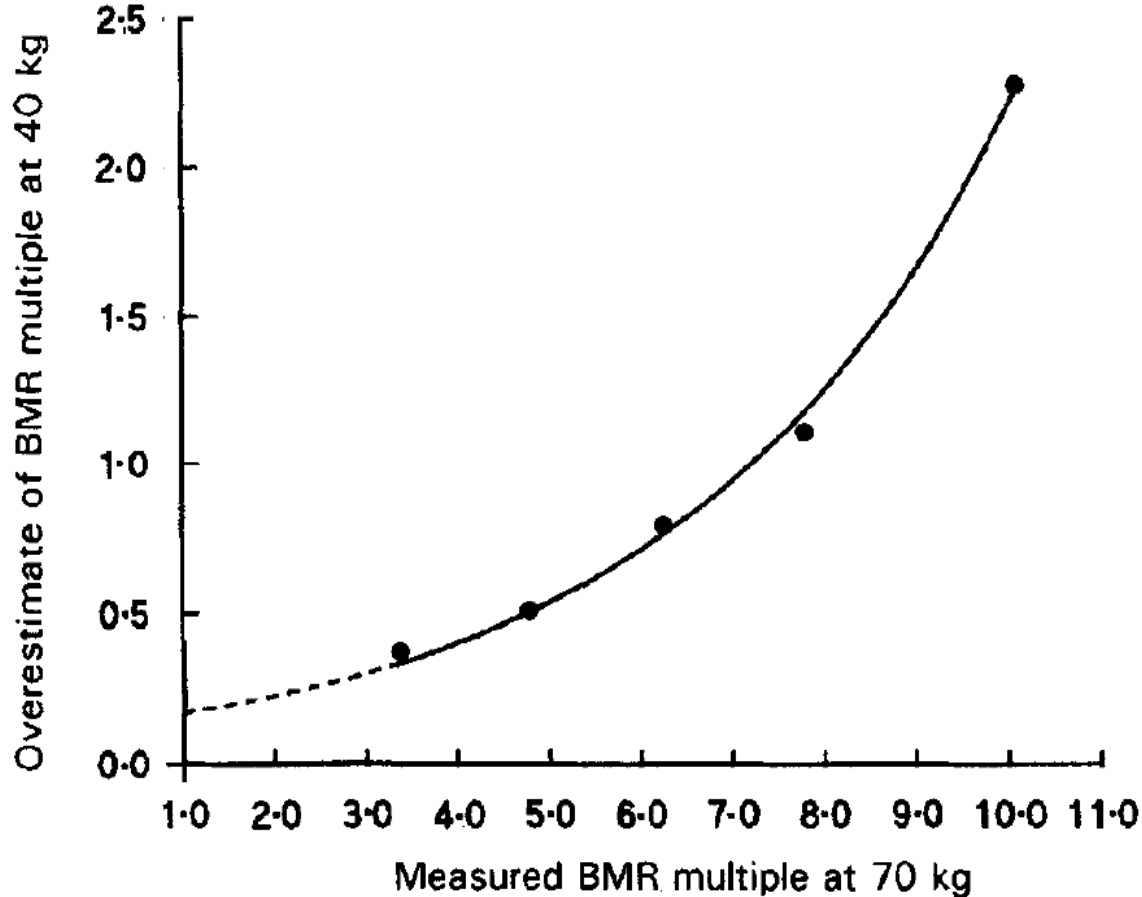
**Table 2a: Comparison of PAR values for adult males from different studies**

Activities	FAO/WHO/UNU (2004)	ICMR (2010) <sup>#</sup>	Banerjee <i>et al.</i> (1972)	Bandyopadhyay <i>et al.</i> (1980)	Kanade <i>et al.</i> (2001)	Kuriyan <i>et al.</i> (2006)
Sleeping	1.0	1.0	-	-	1.0	1.0
Lying resting	1.2	-	-	1.07	-	-
Sitting	1.2	1.5	1.06	1.16	1.25	1.22
Standing	1.4	-	1.43	1.23	1.46	1.29
Personal care (dressing, bathing etc.)	2.4	2.3	-	1.64	-	-
Eating	1.4	1.5	-	1.16	-	-
Household work (general)	2.8 <sup>^</sup>	2.5	-	-	-	-
Light leisure activity	-	1.4	-	-	-	-
Desk-work (sitting and writing)	1.4	1.5	1.14	1.36	-	1.32
Sitting and reading			1.06	1.28		
Ironing	3.5	-	-	-	-	1.64
Sweeping	-	-	-	-	-	3.67
Dusting	-	-	-	-	-	1.56
Cycling	5.6	-	-	-	-	3.33
Walking at 3-2 km/hr	2.8 <sup>*</sup>	2.0	3.07	2.62	-	3.06
Walking at 4-8 km/hr	3.8 <sup>†</sup>	3.2	-	-	-	3.88
Running (7-9 km/hr)	6.34	-	6.34	-	-	-

<sup>#</sup> PAR values are same for both males and females; <sup>^</sup>Given only for females; <sup>\*</sup> Walking slow; <sup>†</sup> Walking quickly

- Studies on Indian population showed that PAR is significantly different from PAR reported by FAO/WHO/UNU, 2004
- Could translate into significant differences in an summed index of activity
- Population-specific PAR values

# PAR – Different for same activity; Interactions to body weight

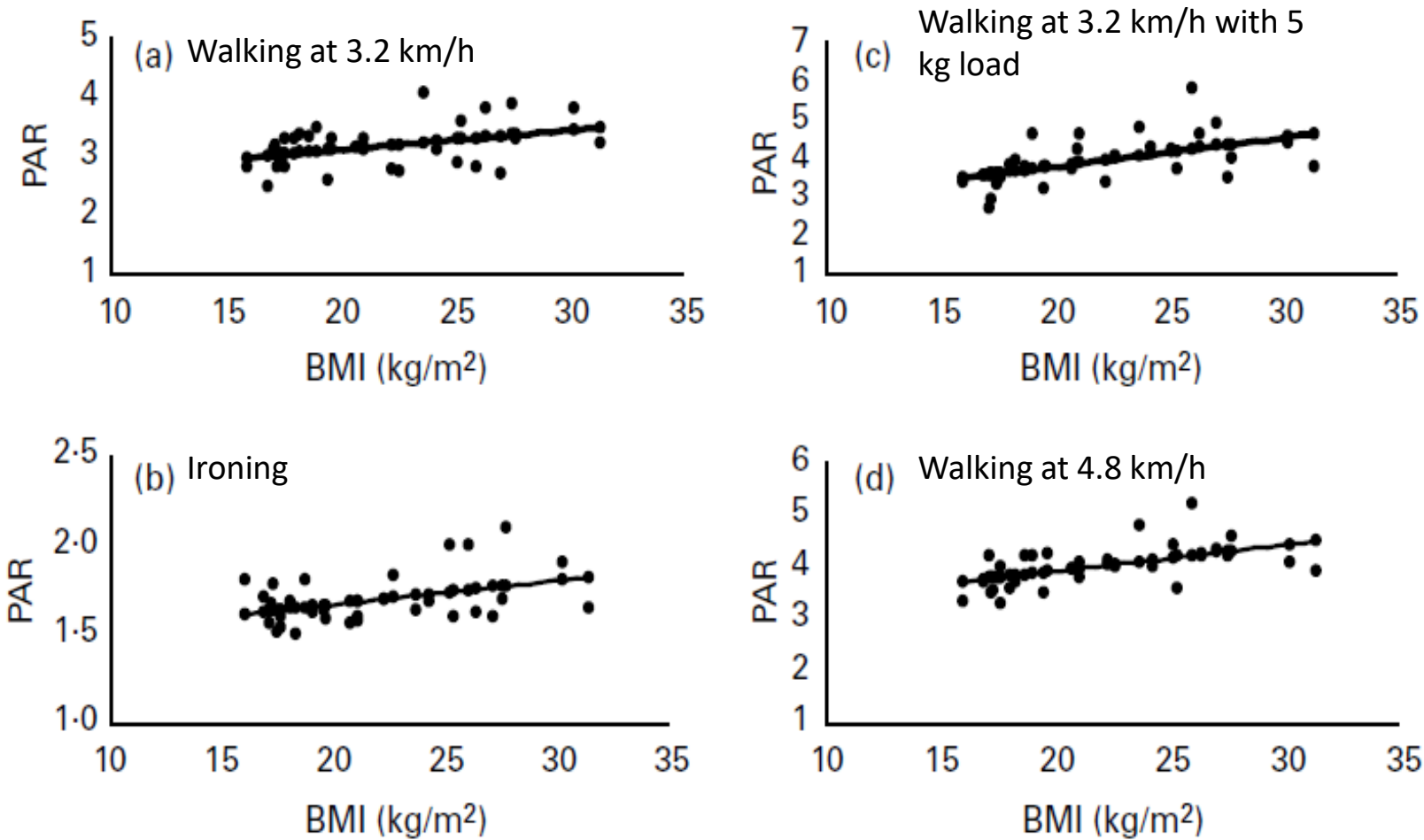


Extrapolation of PAR measured in 70 kg individual to a 40 kg individual overestimates the energy cost of an activity

Using same PAR, regardless of body weight, to express energy cost of each activity can introduce potential errors

## Physical activity ratio of selected activities in Indian male and female subjects and its relationship with body mass index

Rebecca Kuriyan<sup>1\*</sup>, Parvathi P. Easwaran<sup>2</sup> and Anura V. Kurpad<sup>1</sup>



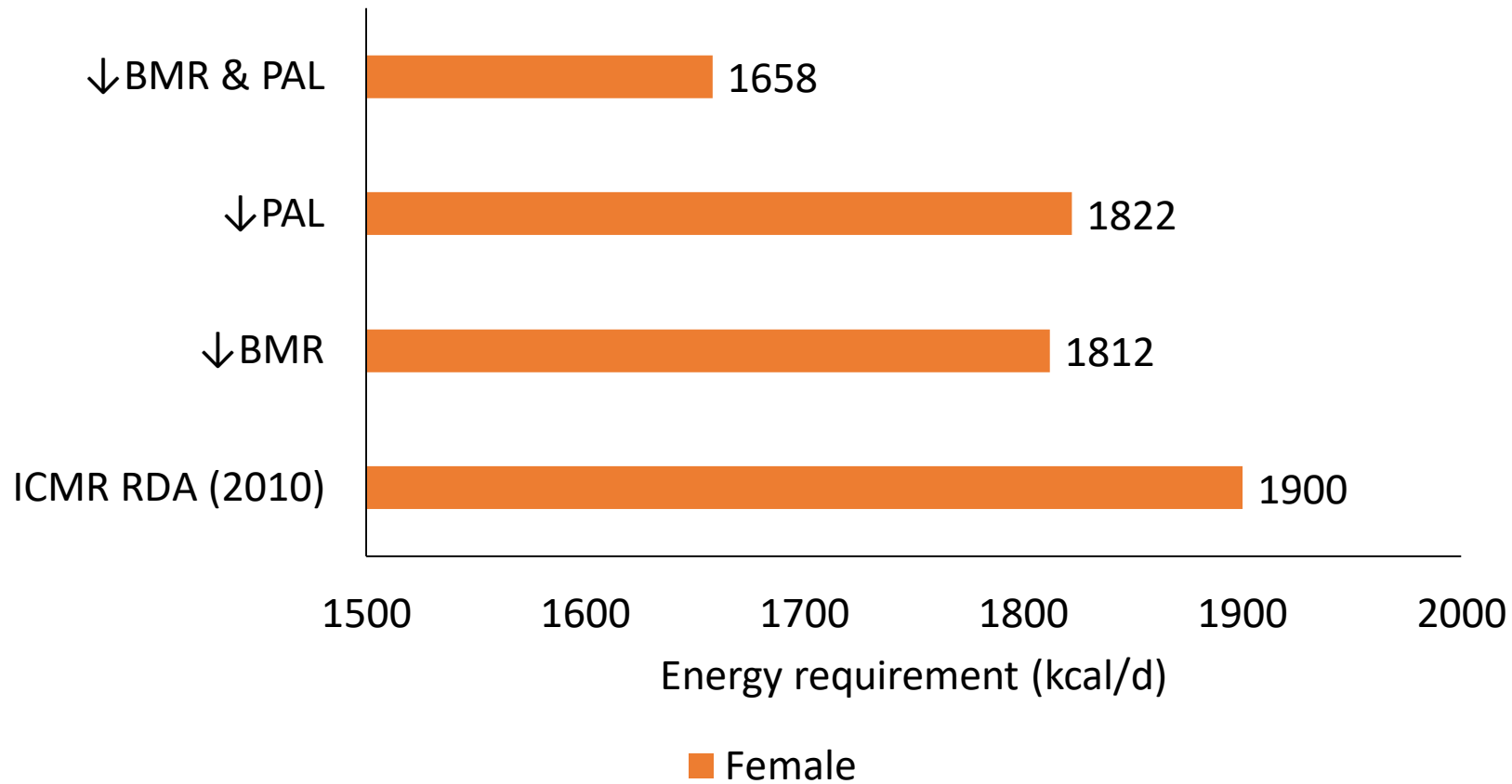
Relationship between BMI and PAR among males (n=30)  
Correlations are significant



# Recommendations for PAL

Activity	Sedentary	Moderate	Heavy
<b>FAO/WHO/UNU 1985</b>			
• Males	1.55	1.78	2.1
• Females	1.56	1.64	1.82
<b>FAO/WHO/UNU 2004</b>			
• Males and females	1.40-1.69	1.7-1.99	2.0-2.40
<b>ICMR 2010</b>			
• Males and females	1.53	1.8	2.3

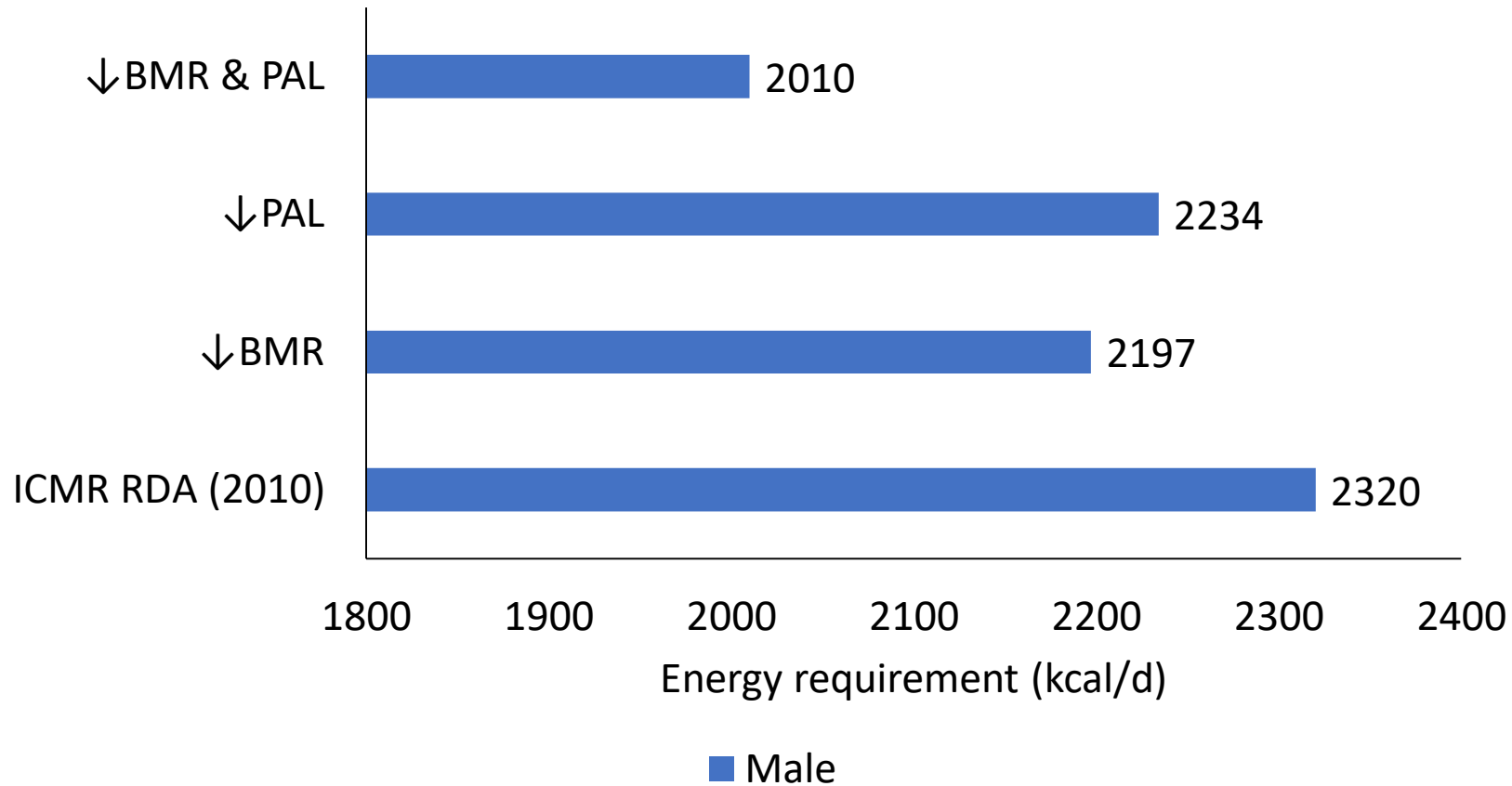
# Energy Requirement – Current Vs Tentative



BMR – 9% lower than  
FAO/WHO/UNU, 2004  
equations

PAL – Lower bound from  
FAO/WHO/UNU, 2004 for  
sedentary (1.4-1.69)

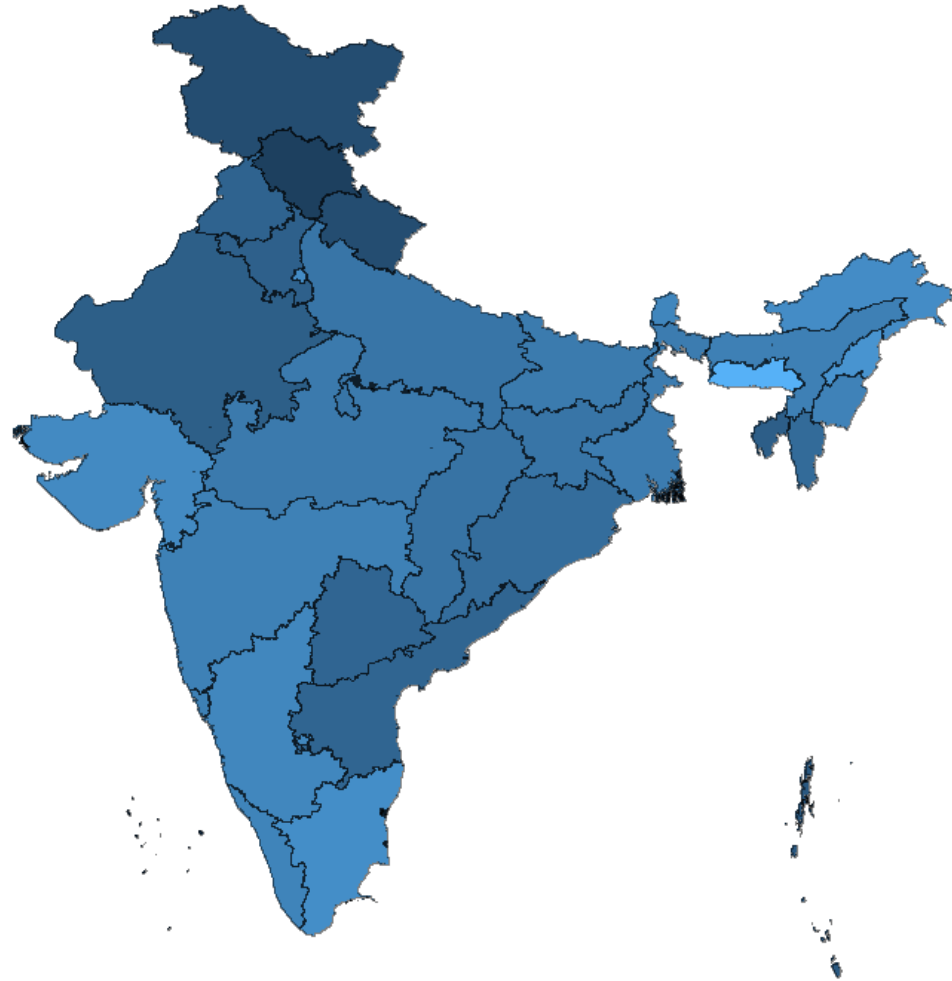
# Energy Requirement – Current Vs Tentative



BMR – 10% lower than  
FAO/WHO/UNU, 2004  
equations

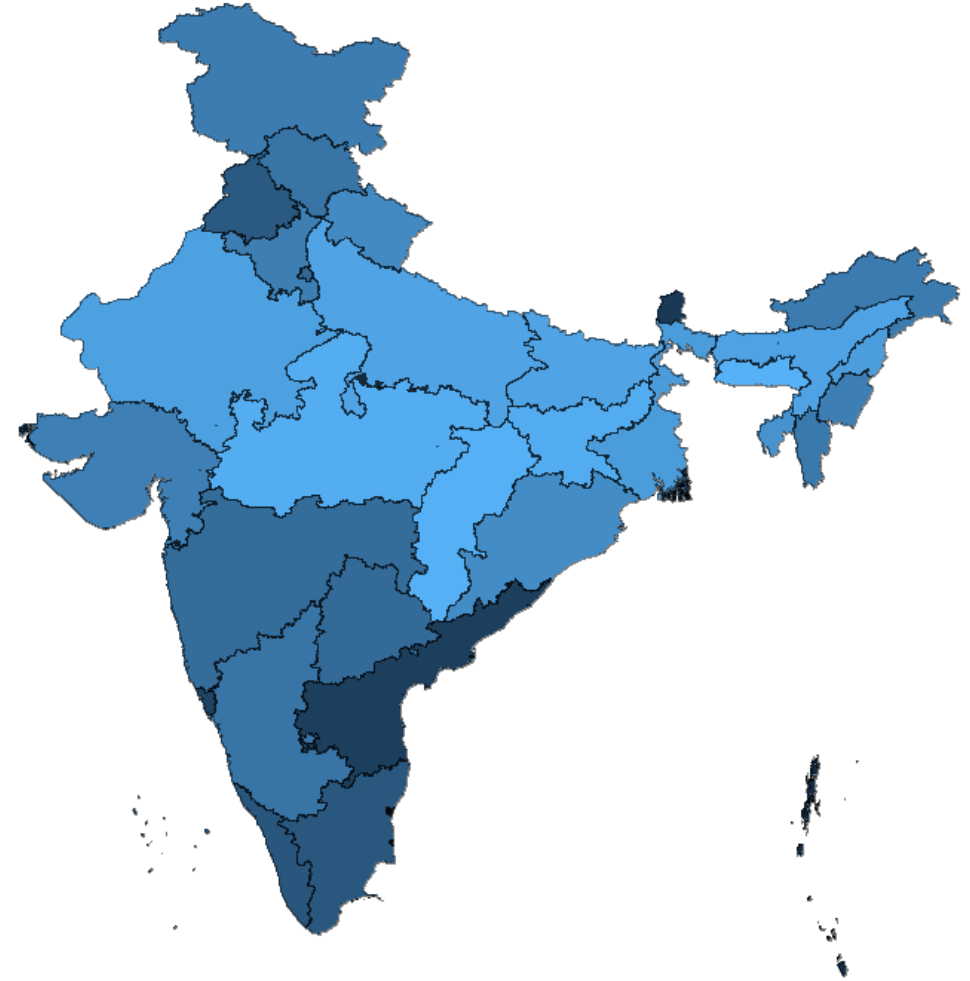
PAL – Lower bound from  
FAO/WHO/UNU, 2004 for  
sedentary (1.4-1.69)

Men's Average energy intake (kcal/d)



2250 2500 2750

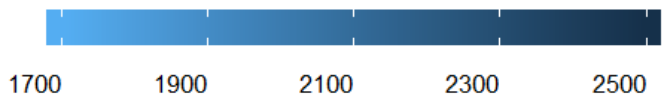
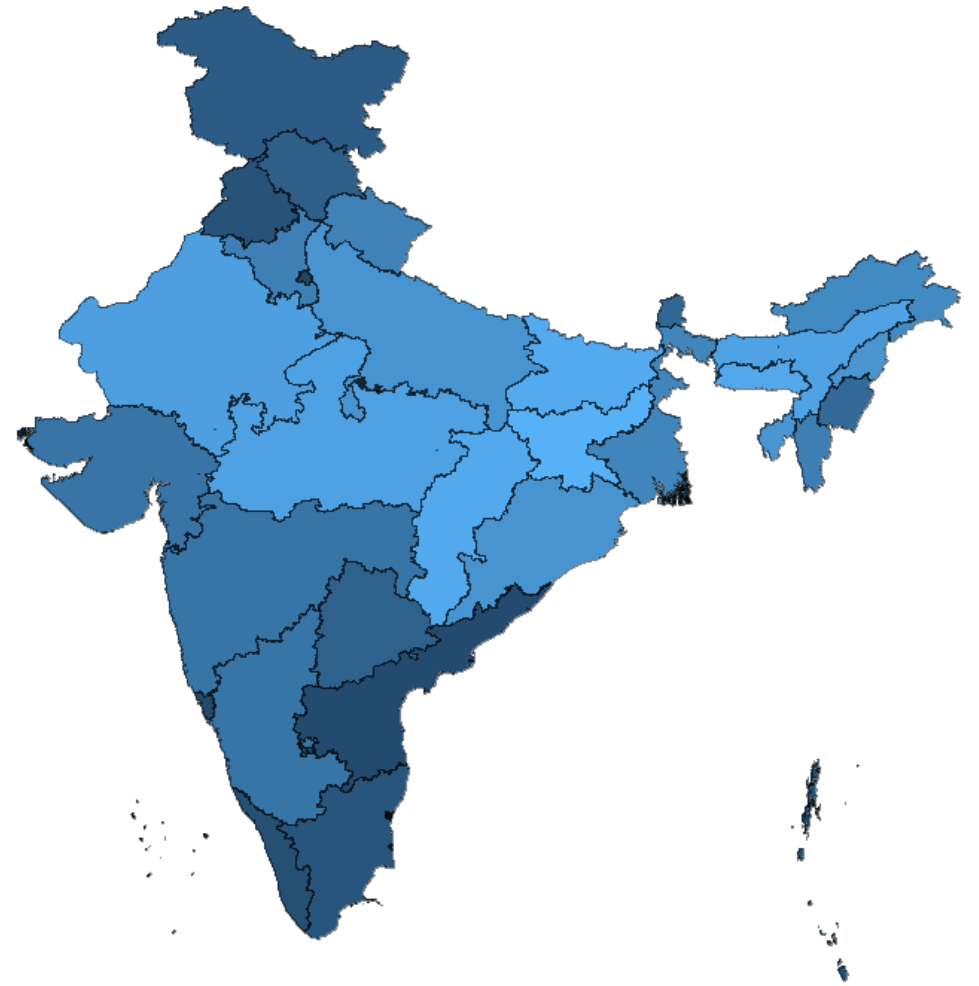
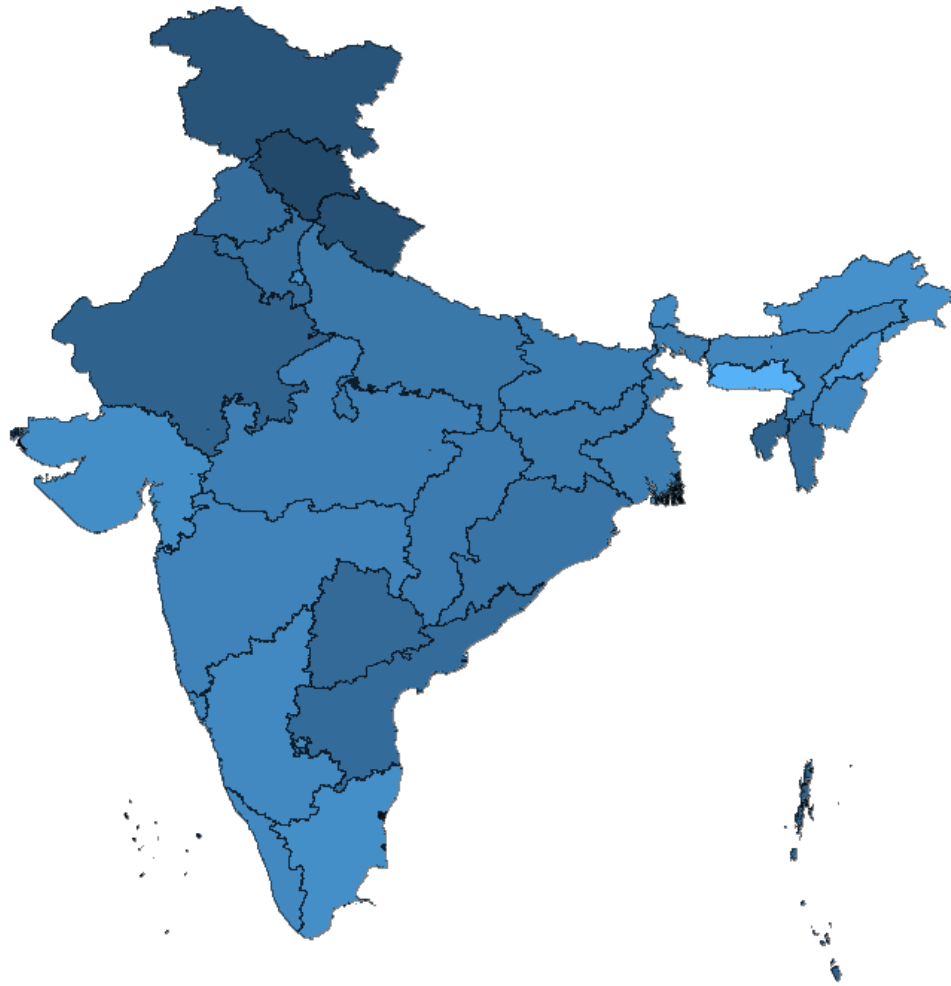
Men's Obesity Rates (%)



20 30

Women's Average energy intake (kcal/d)

Women's Obesity Rates (%)



- Chand and Jurmani (2013) – used ICMR-2010 requirement and FAO – found that prevalence of undernourishment in BPL persons was 30% higher with ICMR norm, compared to FAO norm
- A recalculation based on the new tentative reduced energy requirement
- *A work in progress*- only sedentary recalculation available at this time

# Computation of revised energy requirement – using Rangarajan Ctte method

Age	Sex	Activity	Population weights(Rural)*	Population weights(Urban)*	Energy requirement (kcal) (ICMR)- 2010	Revised energy requirement (kcal)
less than 1			1.79	1.44	585	585
1 to 3			6.07	4.83	1060	1060
4 to 6			6.7	5.19	1350	1350
7 to 9			6.65	5.24	1690	1690
10 to 12			7.33	5.85	2100	2100
13 to 14	Male		2.22	1.92	2750	2750
	Female		2.06	1.76	2330	2330
15 to 59	Male	Sedentary	<b>3.67</b>	<b>13.66</b>	<b>2320</b>	<b>2021</b>
		Moderate	12.78	9.03	2730	2730
		Heavy	7.93	3.84	3490	3490
		Non-worker	<b>5.35</b>	<b>7.31</b>	<b>2320</b>	<b>2021</b>
15 to 59	Female	Sedentary	<b>1.05</b>	<b>3.43</b>	<b>1900</b>	<b>1656</b>
		Moderate	5.45	1.64	2230	2230
		Heavy	4.03	1.53	2850	2850
		Non-worker	<b>17.78</b>	<b>24.84</b>	<b>1900</b>	<b>1656</b>
60 & above#	Male		<b>4.32</b>	<b>4</b>	<b>2320</b>	<b>2021</b>
	Female		<b>4.47</b>	<b>4.11</b>	<b>1900</b>	<b>1656</b>
<b>Energy requirement (kcal)*</b>			<b>2155</b>	<b>2090</b>		
<b>New requirement (kcal)</b>			<b>2058</b>	<b>1936</b>		

\*Planning commission, 2014. The population weights are based on the proportion of each population represented as the population structure in the 2011 Census of India separately for rural and urban sectors. This is specific to age, sex and occupation (used as a proxy for activity). #Calculated for sedentary workers

Prevalence of undernourished in BPL with new tentative energy requirement was

- 10% lower (70 to 60%) in rural

and

- 15% lower (68 to 53%) in urban sector

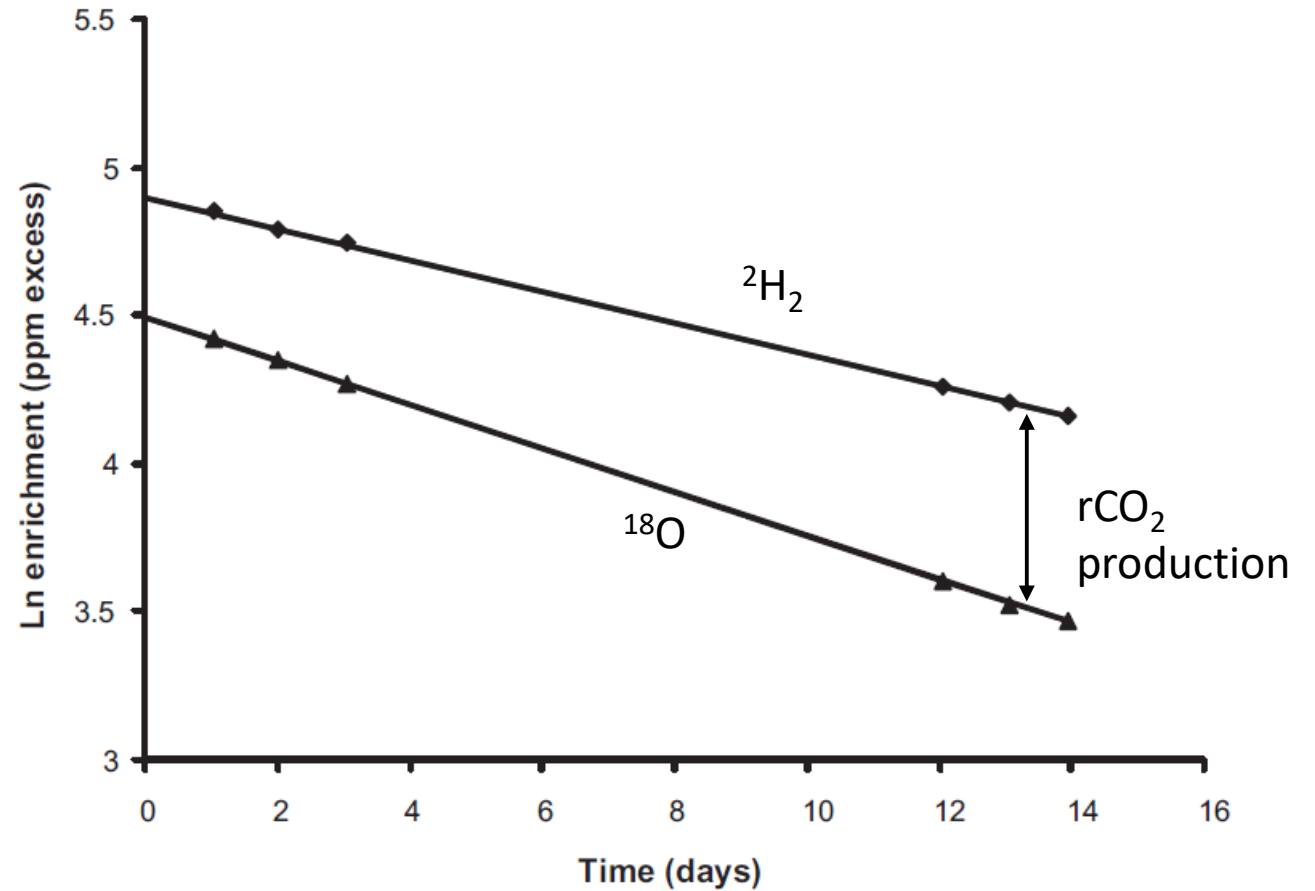
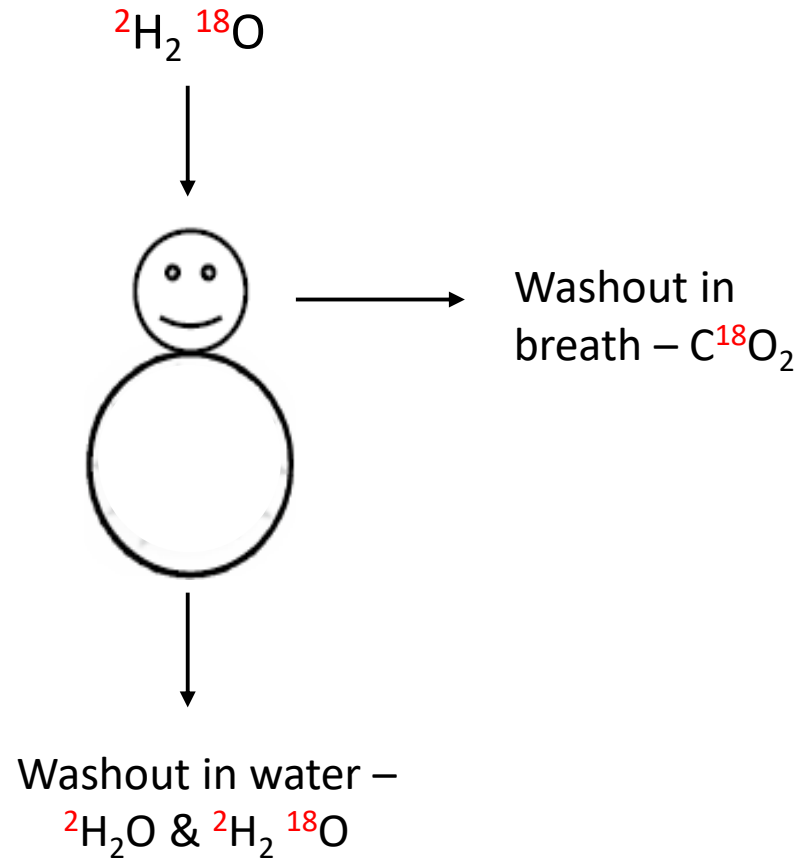
- *Note: only recalculated with new norms for sedentary and elderly*



The quality of that energy intake is  
another matter entirely

A search for validity of  
these estimates

# The use of Doubly Labelled Water ( $^2\text{H}_2^{18}\text{O}$ ) to measure energy expenditure over 2 weeks



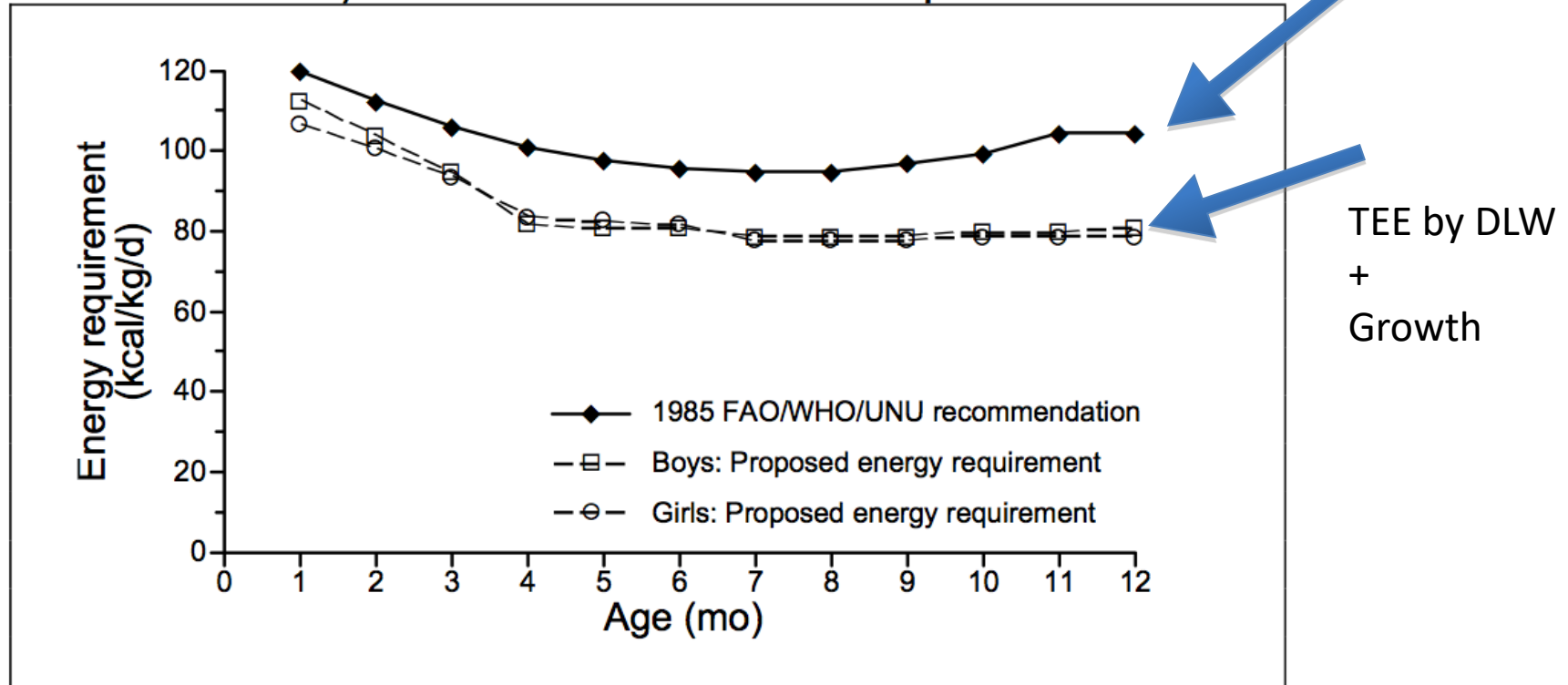
TEE (kcal/d) calculated using modified Weir's equation

# 2005: A reduction in ER of infants

DLW measures + energy deposited in growth

FIGURE 3.2

Comparison of present estimates of energy requirements of infants (combining breastfed and formula-fed infants) with those in the 1985 FAO/WHO/UNU report

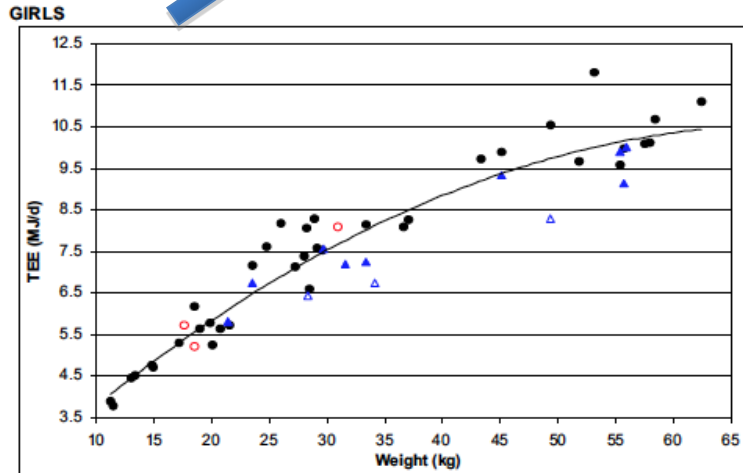
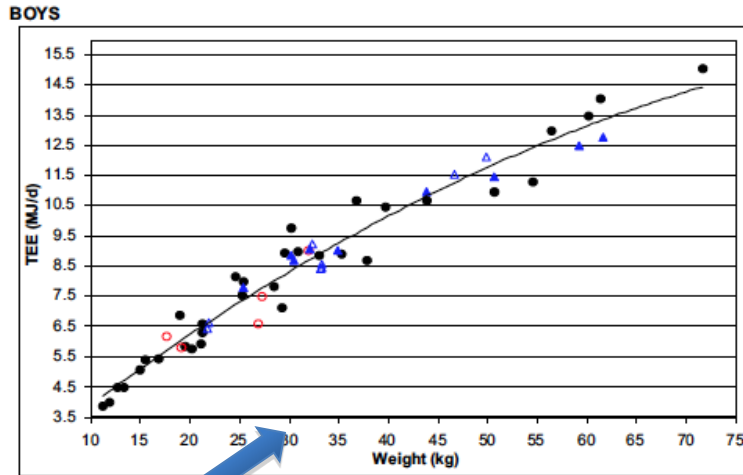


Source: Butte, 2001.

# 2005: Children to boys and girls

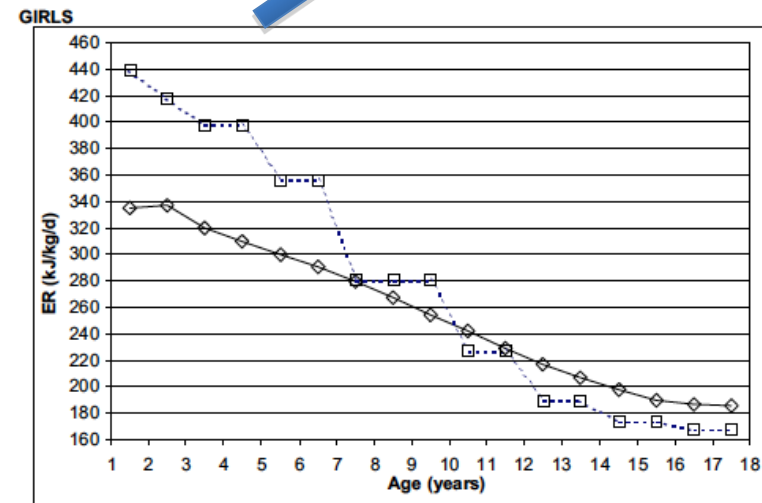
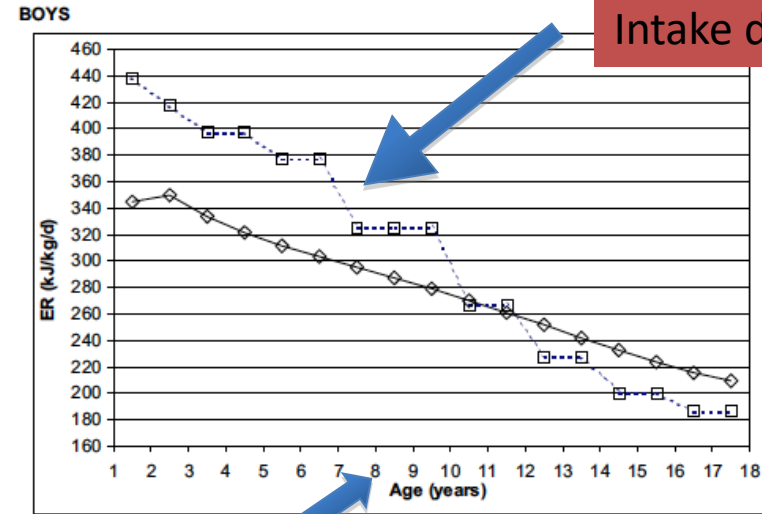
## DLW regressed on average weight

FIGURE 4.1  
Quadratic polynomial regression of total energy expenditure on body weight, weighting each data point by the number of children in the study



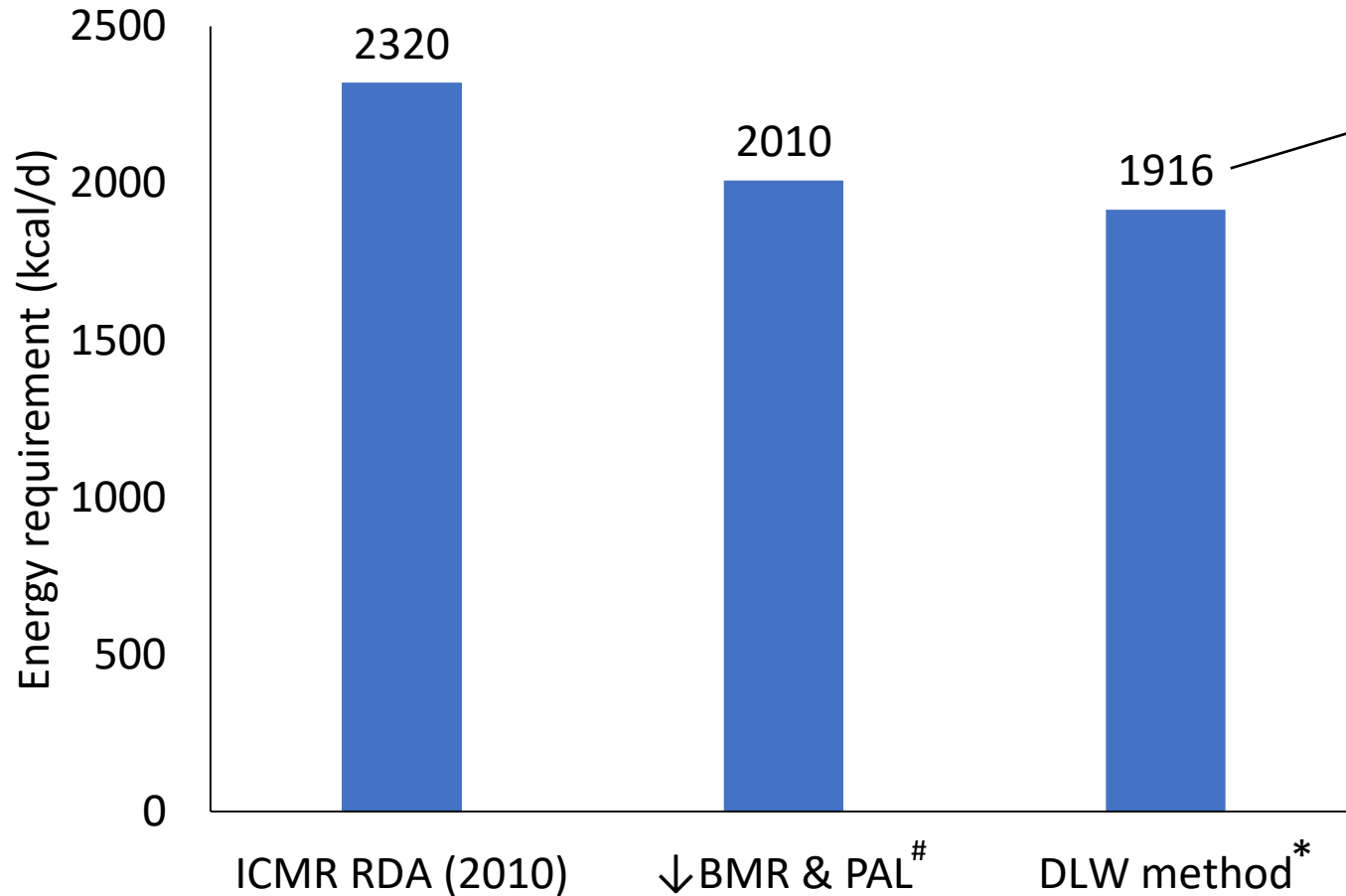
Boys:  $y = 1.298 + 0.265x - 0.0011x^2$ ;  $n_{\text{weight}} = 801$ ,  $r = 0.982$ ,  $\text{see} = 0.518$ .  
 Girls:  $y = 1.102 + 0.273x - 0.0019x^2$ ;  $n_{\text{weight}} = 808$ ,  $r = 0.955$ ,  $\text{see} = 0.650$ .  
 Solid circles: DLW, industrialized countries. Clear circles: DLW, developing countries.  
 Solid triangles: HRM, industrialized countries. Clear triangles: HRM, developing countries.  
 Source: Torun, 2001.

FIGURE 4.2  
Comparison of proposed energy requirements with FAO/WHO/UNU 1985 requirements



Continuous line: proposed energy requirements. Interrupted line: 1985 requirements.  
 Source: Torun, 2001.

# Current Research on Energy Requirement for Millennials – a validation



Preliminary results	
Variable	Mean (± SD)
Age (y)	20.4 ± 0.54
Weight (kg)	59.37 ± 7.09
BMI (kg/m <sup>2</sup> )	19.28 ± 0.82
TEE (kcal/d)	1916 ± 456
BMR (kcal/d)	1524 ± 105
PAL	1.25 ± 0.2
PAEE (kcal/d)	284 ± 108

<sup>#</sup>BMR lowered to 10% as per literature and lower bound of PAL recommended by FAO/WHO/UNU, 2004 was considered;

<sup>\*</sup>Results from our ongoing study on young adult male - TEE measured using DLW; (n=5)

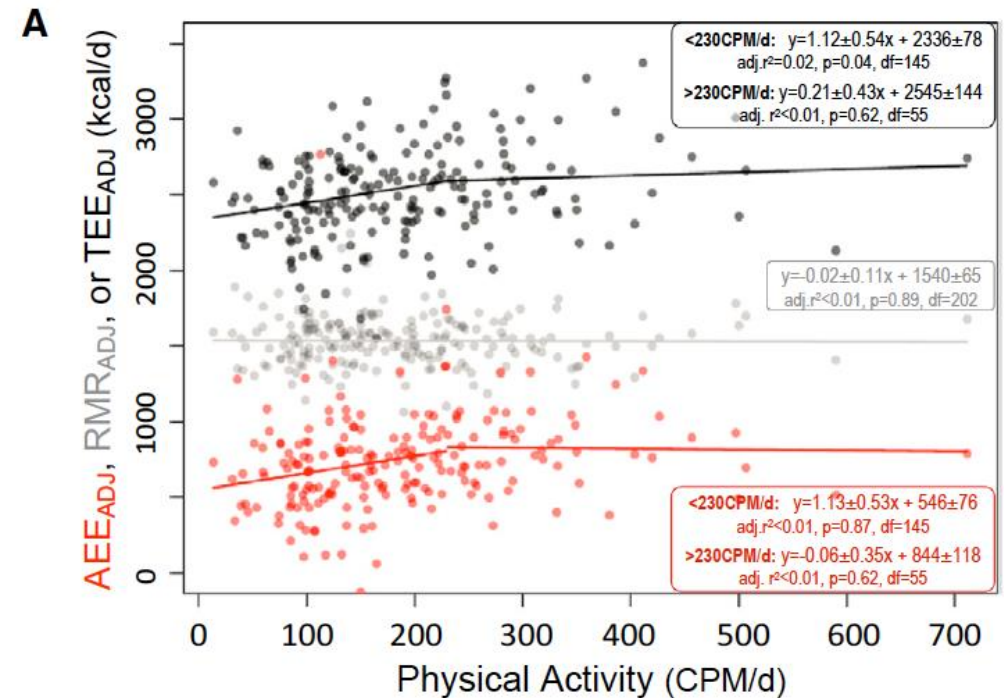
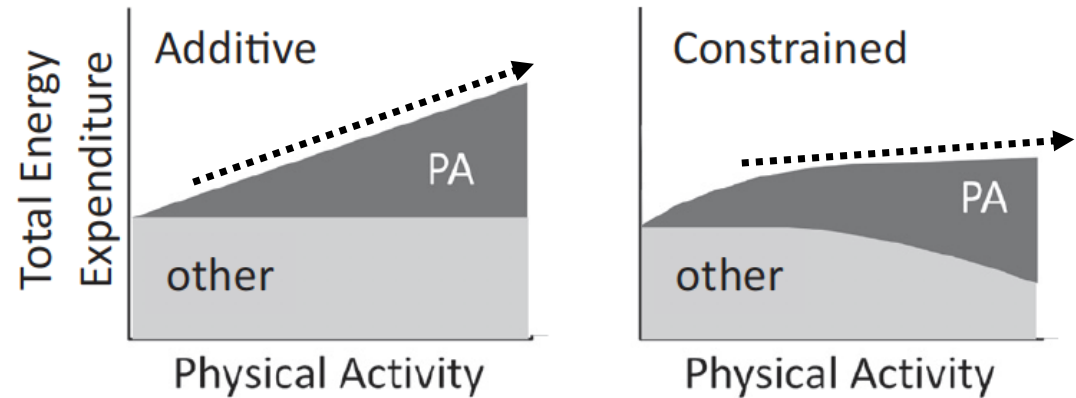
# Factorial method of estimating the requirement...and physiology

Report

## Current Biology

### Constrained Total Energy Expenditure and Metabolic Adaptation to Physical Activity in Adult Humans

- Activity driven TEE plateaus after a certain point
- Non-muscular EE can reduce
- Behavioral adaptation



# Conclusion

- Energy expenditure is low and therefore requirement is not what we thought
- Potential errors can emerge due to factorial approach
- Sedentary behavior has increased- the joys of mechanization
- Overweight is doubling and tripling, along with NCD
- In preventing obesity and related health outcomes, both reduced energy intake and increased physical activity is required



# What's coming? Reducing our calories



Country	Type	n	kCal	Wt (g)
India	Full service	10	1414	855
	Fast food	10	1129	731
US	Full service	71	1362	741
	Fast food	19	969	475

Plain Rice, Dhal , Roti, Paneer Curry, Mixed Veg, Onion Rings, Kesari bhath (Dessert)	1428
Plain Rice, Dhal , Phulka (Chapathi), Chicken Curry, Chicken Tandoori, Onion Curry, Kesari bhath (Dessert)	1407
Masala Dosa, Potato Palya, Coconut Chutney, Sambar	1024
Roti, Paneer Gravy, Vegetable Sabzi, Dhal, Flavored Rice, Curd Rice, Papad, Sabzi, Pickle	→ 1809
Fish Biryani, Fish gravy, Fish kebab, salad, Raitha, Wafers	1407
Prawn biryani, Prawn gravy, Prawn kebab, Salad, Raitha, Wafers	1241
Fried Rice, Tomato Sauce, Chili Sauce	719
Aloo Parata, Curd Rice, Sabzi	896
Kamiri Roti , Paneer Butter Masala	→ 1541
Jeera Rice, Chicken Hyderabad, Mixed Veg Salad	→ 1891
Chicken Sandwich, French fries	1053
Meat Mojo Burger	567
Roti, Butter Chicken, Onion Salad,	1289
Chicken Chatpata, Onion Salad, Green Chutney	915
Chicken Fried Rice, Chicken Hunan	→ 2234
Veg Koi Thoi , Mixed veg in Oyster Sauce, Red Chili Sauce, Brine with Green Chutney	→ 1748
Rice, Dal, Rasam, Vegetable Palya, Green Chutney, Curd, Papad	1437
Mutton Biryani, Gravy, Raitha	1464



