



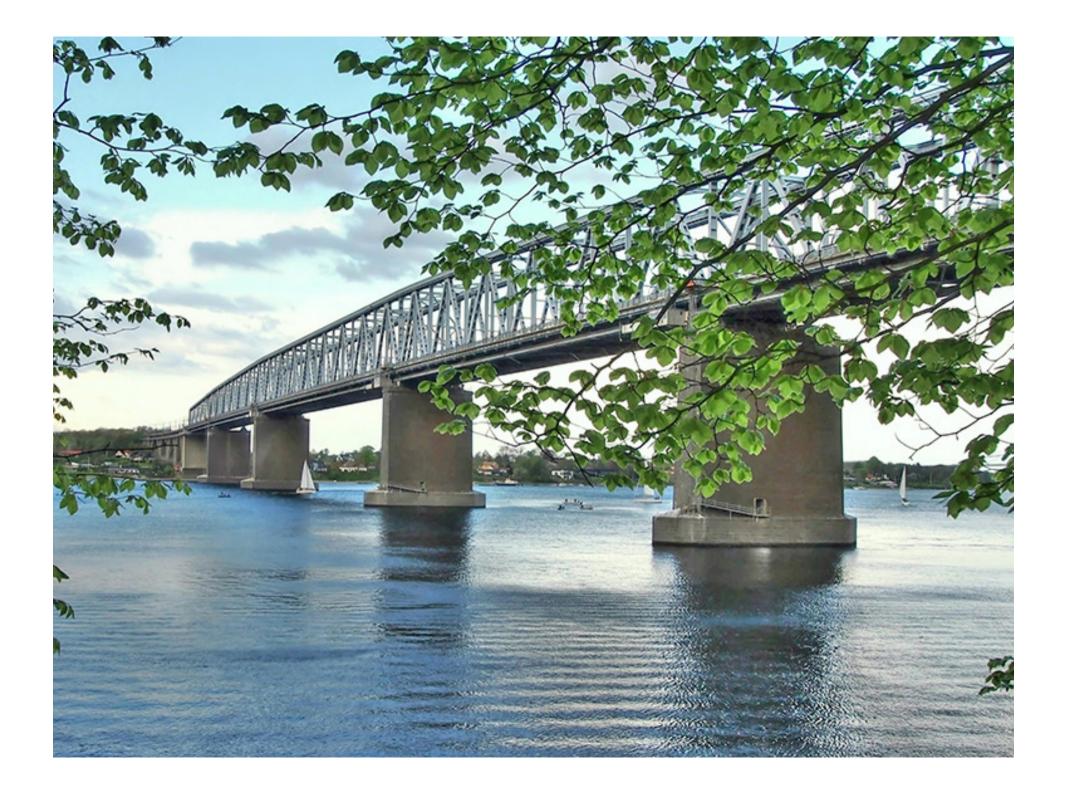


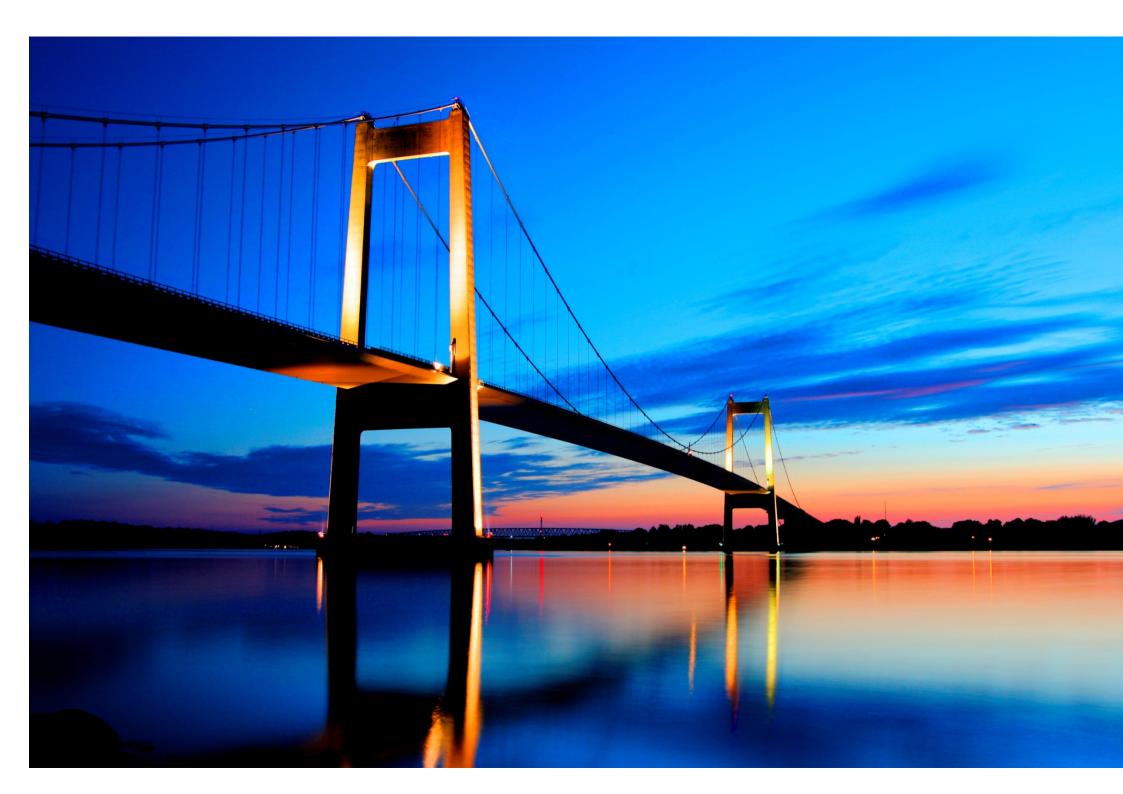
Harmonisation of physical activity data Methodological challenges and potential solutions

Søren Brage

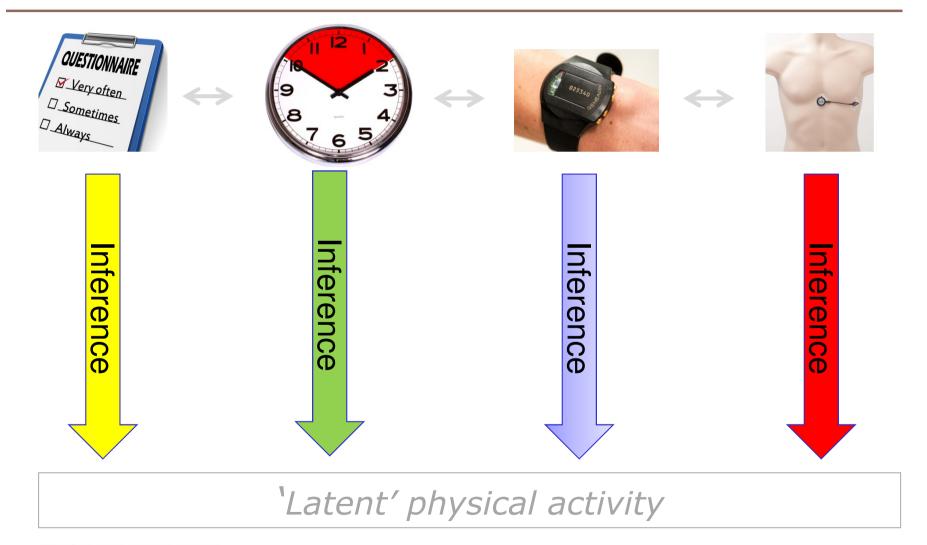
ISPAH Data Harmonisation Satelite meeting, Cambridge

18<sup>th</sup> October 2018

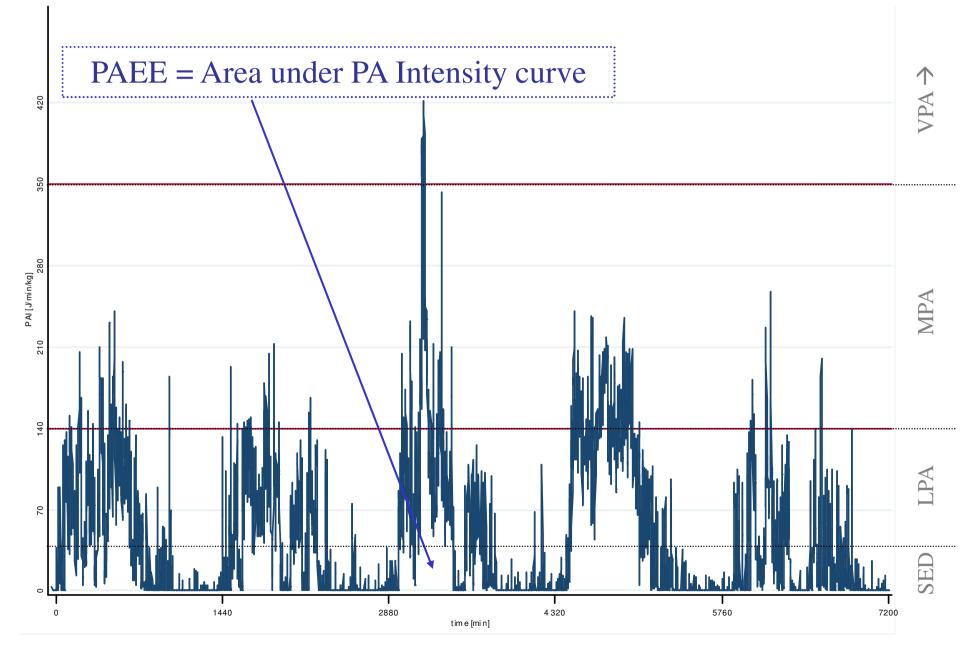




## Different measurements, same underlying target

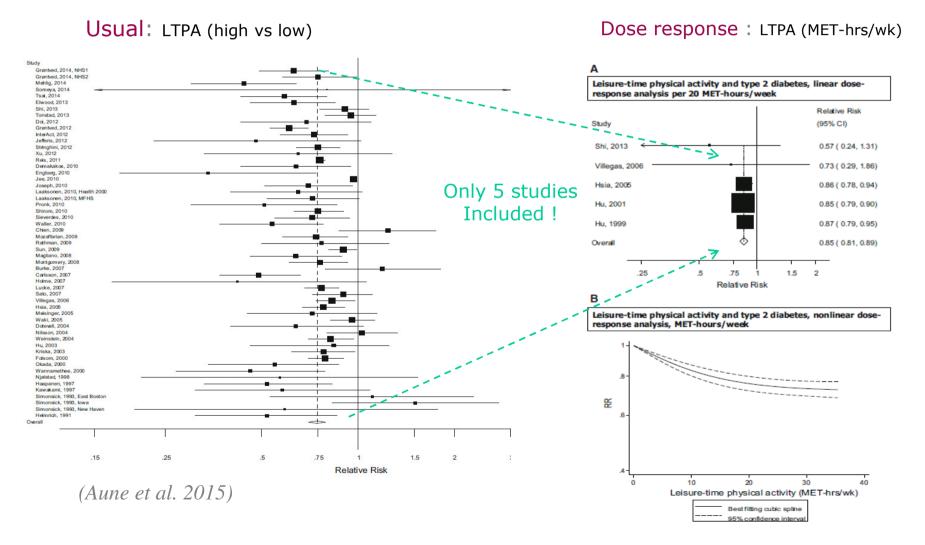






## Total vs actioned evidence base...

## A typical meta-analysis...



# Can we **bring harmony** to the un-harmonisable ("harmomiserable")?





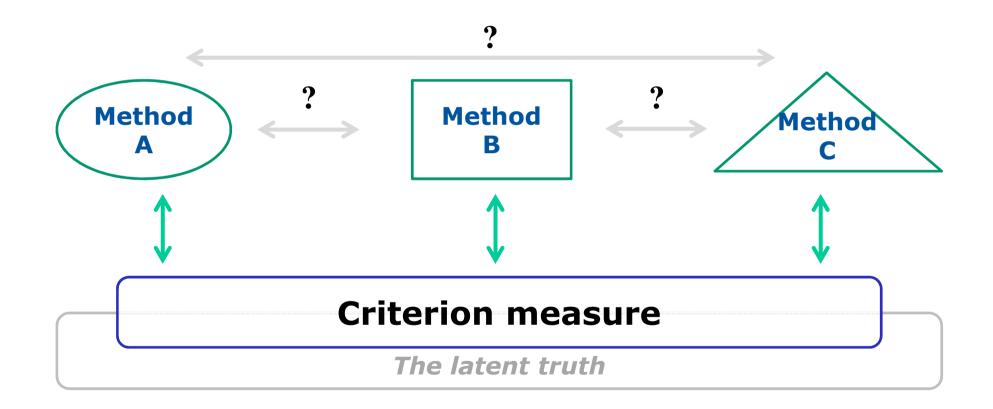
## **Some options**

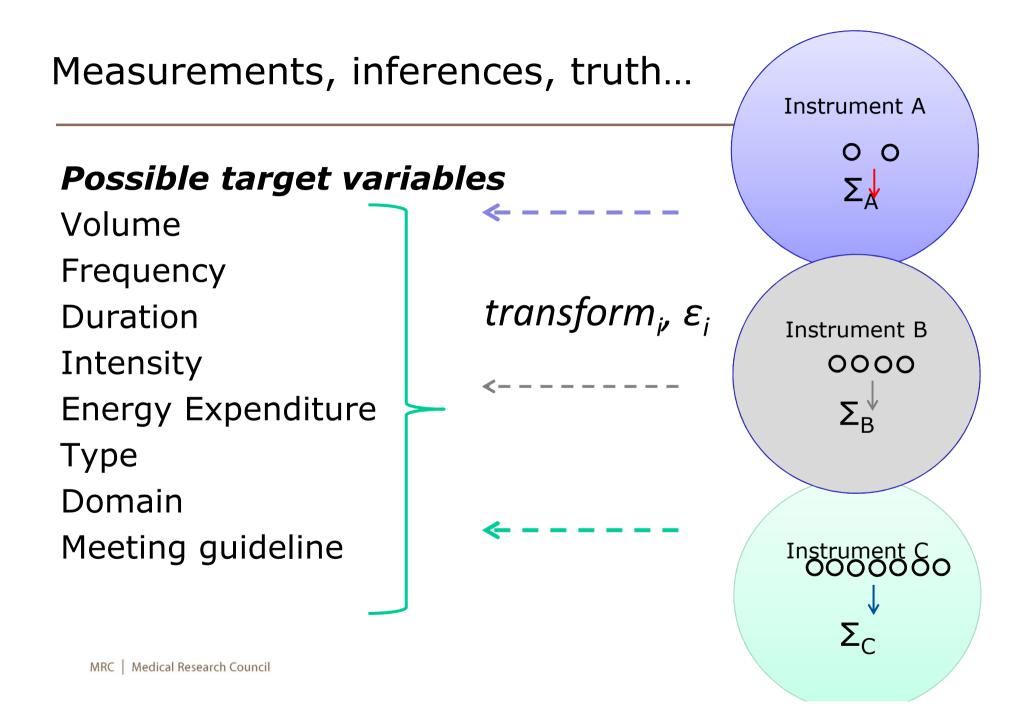
1. Be bold! Make assumptions (and test them!)

## **2.** Bring more data into the mix

- Harmonisation using validation data
- Validation and Marginalisation
- Harmonisation using indirect validation
- Measurement error correction methodology

## Chasing the truth...





The transforms have two key characteristics:

- **1. Mapping**: Method X values to target values
- 2. Uncertainty estimator of the mapping

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#### **B Z 1 Dose-response Meta-analysis -** Motivating Example

₩ FIII.\* Sort & Find & Filter \* Select \* Editing

A	В	С	D	E	F	G	Н	1	J	k
STUDY	YEAR	location	PA DOMAIN	PA MEASUREMENT TOOL	PA Units	EFFECT TYPE	PA CATs	EFFECT SIZE	LCI	U
EPIC-Europe	2015	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	<45 METs/wk	1		-
EPIC-Europe	2015	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	45-69 METs/wk	0.97	0.91	1.
EPIC-Europe	2015	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	69–96 METs/wk	0.94	0.89	1.
EPIC-Europe	2015	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	96-134 METs/wk	0.9	0.83	0
EPIC-Europe	2015	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	134 METs/wk	0.87	0.8	0
Danish Nurse Cohort Study	2015	Denmark	LTPA	questionnaire (Saltin and Grimby)	category	HR	Sedentary	1.62	1.15	2
Danish Nurse Cohort Study	2015	Denmark	LTPA	questionnaire (Saltin and Grimby)	category	HR	Moderate	1.1	0.91	1
Danish Nurse Cohort Study	2015	Denmark	LTPA	questionnaire (Saltin and Grimby)	category	HR	Vigorous	1		
Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	Low	1		
Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	Moderate	1.01	0.64	1
Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	High	0.95	0.4	2
Black Women's Health Study	2016	USA	LTPA				1	1		
	2016			questionnaire	category	HR	Low	0.91	0.55	
Black Women's Health Study Black Women's Health Study	2016	USA	LTPA LTPA	questionnaire questionnaire	category category	HR	Moderate High	0.91	0.55	1
,				2	, ,					
Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	Low	1		
Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	Moderate	0.98	0.87	1
Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	High	0.85	0.74	(
EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	<45 METs/wk	1		
EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	45-69 METs/wk	1	0.942	1
EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	69–96 METs/wk	0.998	0.939	1
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EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	134 METs/wk	0.987	0.926	1
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EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	45–69 METs/wk	0.983	0.938	1
EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	69–96 METs/wk	0.944	0.899	(
EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	96–134 METs/wk	0.932	0.886	(
EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	134 METs/wk	0.911	0.863	0
Sax Institute's 45 and Up study	2016	Australia	MV-LTPA	questionnaire (http://www.45andUp.org.au)	mins/wk MVPA	HR	0 - 10 min/wk of MVPA	1		
Sax Institute's 45 and Up study	2016	Australia	MV-LTPA	questionnaire (http://www.45andUp.org.au)	mins/wk MVPA		10 - 149 min/wk of MVPA	0.66	0.61	(
Sax Institute's 45 and Up study	2016	Australia	MV-LTPA	questionnaire (http://www.45andUp.org.au)	mins/wk MVPA		150 - 299 min/wk of MVPA	0.53	0.48	(
Sax Institute's 45 and Up study	2016	Australia	MV-LTPA	questionnaire (http://www.45andUp.org.au)	mins/wk MVPA		≥ 300 min/wk of MVPA	0.46	0.43	(
Sax Institute's 45 and Up study	2016	Australia	MV-LTPA	questionnaire (http://www.45andUp.org.au)	category	HR	0% of MVPA from VPA	1		
Sax Institute's 45 and 0p study	2016	Australia	MV-LTPA	questionnaire (http://www.45and0p.org.au) questionnaire (http://www.45andUp.org.au)	category	HR	>0% to <30% of MVPA from VPA	0.89	0.81	(
Sax Institute's 45 and Up study Sax Institute's 45 and Up study	2016	Australia	MV-LTPA	questionnaire (http://www.45and0p.org.au) questionnaire (http://www.45andUp.org.au)	category	HR	≥30% of MVPA from VPA	0.86	0.79	0
EPIC - Italy	2016	Italy	LTPA	EPIC lifestyle questionnaire	MET-hr/wk	HR	<73.9	1		
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### **B** *I* **1 Dose-response Meta-analysis -** Motivating Example

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4	A	В	С	D	E	F	G	Н	1	J	K
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I	Danish Nurse Cohort Study	2015	Denmark	LTPA	questionnaire (Saltin and Grimby)	category	HR	Moderate	1.1	0.91	1.3
I	Danish Nurse Cohort Study	2015	Denmark	LTPA	questionnaire (Saltin and Grimby)	category	HR	Vigorous	1		
I	Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	Low	1		
I	Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	Moderate	1.01	0.64	1.5
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	Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	High	0.58	0.22	1.5
	Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	Low	1		
	Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	Moderate	0.98	0.87	1.0
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### **B** *I* **1 Dose-response Meta-analysis -** Motivating Example

₩ FIII.\* ----Sort & Find & Q Clear ▼ Filter \* Select \* Editing

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+	Danish Nurse Cohort Study	2015	Denmark	LTPA	questionnaire (Saltin and Grimby)	category	HR	Sedentary	1.62	1.15	2.27
	Danish Nurse Cohort Study	2015	Denmark	LTPA	questionnaire (Saltin and Grimby)	category	HR	Moderate	1.1	0.91	1.33
	Danish Nurse Cohort Study	2015	Denmark	LTPA	questionnaire (Saltin and Grimby)	category	HR	Vigorous	1	0.51	1.00
				1754				•			
	Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	Low	1	0.54	
	Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	Moderate	1.01	0.64	1.5
+	Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	High	0.95	0.4	2.2
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	Dis shawe so of the life Origin	2016	110.4	LTPA				1			
-	Black Women's Health Study Black Women's Health Study	2016 2016	USA	LTPA	questionnaire	category	HR	Low Moderate	1 0.98	0.87	1.0
	Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	High	0.98	0.87	0.9
	black women's health study	2010	USA	LIFA	questionnaire	category	пк	nign	0.65	0.74	0.5
F	EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	<45 METs/wk	1		
	EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	45-69 METs/wk	1	0.942	1.0
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	EPIC - Italy	2016	Italy	LTPA	EPIC lifestyle questionnaire	MET-hr/wk	HR	<73.9	1		
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#### **B Z 1 Dose-response Meta-analysis - Motivating Example**

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Α	В	С	D	E	F	G	Н	1	J	K
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		3								
Black Women's Health Stud		USA	LTPA	questionnaire	category	HR	Low	1		
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	dv 2016	Australia	10/1704		mins/wk MVPA	HR	0 - 10 min/wk of MVPA	1		
ax Institute's 45 and Up stu ax Institute's 45 and Up stu		Australia	MV-LTPA MV-LTPA	questionnaire (http://www.45andUp.org.au) questionnaire (http://www.45andUp.org.au	mins/wk MVPA	HR	10 - 149 min/wk of MVPA	0.66	0.61	0
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	uy 2010	Australia		questionnane (http://www.45anaop.org.aa)	11112/11111		2.500 min / WK OF MAT A	0.40	0.40	
ax Institute's 45 and Up stu	dy 2016	Australia	MV-LTPA	questionnaire (http://www.45andUp.org.au)	category	HR	0% of MVPA from VPA	1		
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EPIC - Italy	2016	Italy	LTPA	EPIC lifestyle questionnaire	MET-hr/wk	HR	<73.9	1		
form dictionary			LIPA			пк	<73.9	1		

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### **B** *I* 1 **Dose-response Meta-analysis -** Motivating Example

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1	A STUDY	B YEAR	C location	PA DOMAIN	E PA MEASUREMENT TOOL	F PA Units	G EFFECT TYPE	H PA CATs	EFFECT SIZE	ן רכו	K UCI
2 3	EPIC-Europe	2015	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	<45 METs/wk	1		
4	EPIC-Europe	2015	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	45–69 METs/wk	0.97	0.91	1.04
5	EPIC-Europe	2015	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	69–96 METs/wk	0.94	0.89	1.02
6	EPIC-Europe	2015	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	96–134 METs/wk	0.9	0.83	0.97
7	EPIC-Europe	2015	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	134 METs/wk	0.87	0.8	0.95
8											
9	Danish Nurse Cohort Study	2015	Denmark	LTPA	questionnaire (Saltin and Grimby)	category	HR	Sedentary	1.62	1.15	2.27
10	Danish Nurse Cohort Study	2015	Denmark	LTPA	questionnaire (Saltin and Grimby)	category	HR	Moderate	1.1	0.91	1.33
11	Danish Nurse Cohort Study	2015	Denmark	LTPA	questionnaire (Saltin and Grimby)	category	HR	Vigorous	1		
12								2000			
13	Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	Low	1		
14	Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	Moderate	1.01	0.64	1.58
15	Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	High	0.95	0.4	2.27
16		2015		1754		in and a second second		2010			
17	Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	Low	1	0.55	4.50
8	Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	Moderate	0.91	0.55	1.52
.9 0	Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	High	0.58	0.22	1.57
1	Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	Low	1		
2	Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	Moderate	0.98	0.87	1.09
3	Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	High	0.85	0.74	0.97
24	,										
25	EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	<45 METs/wk	1		
6	EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	45-69 METs/wk	1	0.942	1.062
7	EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	69–96 METs/wk	0.998	0.939	1.061
8	EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	96–134 METs/wk	0.993	0.934	1.05
9	EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintile:	HR	134 METs/wk	0.987	0.926	1.05
80											
1	EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	<45 METs/wk	1		
2	EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	45–69 METs/wk	0.983	0.938	1.02
3	EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	69–96 METs/wk	0.944	0.899	0.99
4	EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	96–134 METs/wk	0.932	0.886	0.98
5	EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	134 METs/wk	0.911	0.863	0.96
6 7	Caulastitute's 45 and 11a study	2016	Australia	MULTDA	eventionen im (http://www.45-adula.even)	mine (ult MM/D	N 110	0.10 min (wh of M/DA	1		
	Sax Institute's 45 and Up study Sax Institute's 45 and Up study	2016	Australia Australia	MV-LTPA MV-LTPA	questionnaire (http://www.45andUp.org.au) questionnaire (http://www.45andUp.org.au)	mins/wk MVP mins/wk MVP	A HR A HR	0 - 10 min/wk of MVPA 10 - 149 min/wk of MVPA	0.66	0.61	0.71
	Sax Institute's 45 and Up study	2016	Australia	MV-LTPA	questionnaire (http://www.45and0p.org.au)	mins/wk MVP	A HR	150 - 299 min/wk of MVPA	0.53	0.01	0.71
	Sax Institute's 45 and Up study	2010	Australia	MV-LTPA	questionnaire (http://www.45and0p.org.au)	mins/wk MVP		≥ 300 min/wk of MVPA	0.35	0.48	0.49
1	Sux mattate 3 45 and op study	2010	Australia		questionnane (http://www.45anaop.org.au/	11113/ WK WW		2 300 min/wkonwin A	0.40	0.40	0.43
	Sax Institute's 45 and Up study	2016	Australia	MV-LTPA	questionnaire (http://www.45andUp.org.au)	category	HR	0% of MVPA from VPA	1		
	Sax Institute's 45 and Up study	2016	Australia	MV-LTPA	questionnaire (http://www.45andUp.org.au)	category	HR	>0% to <30% of MVPA from VPA	0.89	0.81	0.98
	Sax Institute's 45 and Up study	2016	Australia	MV-LTPA	questionnaire (http://www.45andUp.org.au)	category	HR	≥30% of MVPA from VPA	0.86	0.79	0.94
5											
16	EPIC - Italy	2016	Italy	LTPA	EPIC lifestyle questionnaire	MET-hr/wk	HR	<73.9	1		
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#### I Format Painter Clipboard 5

### **B** *I* **1 Dose-response Meta-analysis -** Motivating Example

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	А	В	С	D	E	F	G	н		J	K
	STUDY	YEAR	location	PA DOMAIN	PA MEASUREMENT TOOL	PA Units	EFFECT TYPE	PA CATs	EFFECT SIZE	LCI	UC
	EPIC-Europe	2015	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	<45 METs/wk	1		
	EPIC-Europe	2015	Europe	LTPA (plus household)	EPIC lifestyle guestionnaire	MET quintiles	HR	45-69 METs/wk	0.97	0.91	1.0
	EPIC-Europe	2015	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	69–96 METs/wk	0.94	0.89	1.0
	EPIC-Europe	2015	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	96-134 METs/wk	0.9	0.83	0.
	EPIC-Europe	2015	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	134 METs/wk	0.87	0.8	0.
	Danish Nurse Cohort Study	2015	Denmark	LTPA	questionnaire (Saltin and Grimby)	category	HR	Sedentary	1.62	1.15	2.
	Danish Nurse Cohort Study	2015	Denmark	LTPA	questionnaire (Saltin and Grimby)	category	HR	Moderate	1.1	0.91	1
	Danish Nurse Cohort Study	2015	Denmark	LTPA	questionnaire (Saltin and Grimby)	category	HR	Vigorous	1		
	Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	Low	1		
	Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	Moderate	1.01	0.64	1
	Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	High	0.95	0.4	2
	Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	Low	1		
	Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	Moderate	0.91	0.55	1
	Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	High	0.58	0.22	1
	Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	Low	1		
	Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	Moderate	0.98	0.87	1
	Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	High	0.85	0.74	c
	EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	<45 METs/wk	1		
	EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	45–69 METs/wk	1	0.942	1.
	EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	69–96 METs/wk	0.998	0.939	1
	EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	96–134 METs/wk	0.993	0.934	1
	EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	134 METs/wk	0.987	0.926	1
	EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	<45 METs/wk	1		
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	EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	69–96 METs/wk	0.944	0.899	0
	EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	96–134 METs/wk	0.932	0.886	0
	EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	134 METs/wk	0.911	0.863	0.
5	Sax Institute's 45 and Up study	2016	Australia	MV-LTPA	questionnaire (http://www.45andUp.org.au)	mins/wk MVPA	HR	0 - 10 min/wk of MVPA	1		
	Sax Institute's 45 and Up study	2016	Australia	MV-LTPA	questionnaire (http://www.45andUp.org.au)	mins/wk MVPA		10 - 149 min/wk of MVPA	0.66	0.61	0
5	Sax Institute's 45 and Up study	2016	Australia	MV-LTPA	questionnaire (http://www.45andUp.org.au)	mins/wk MVPA		150 - 299 min/wk of MVPA	0.53	0.48	0
5	Sax Institute's 45 and Up study	2016	Australia	MV-LTPA	questionnaire (http://www.45andUp.org.au)	mins/wk MVPA	HR	≥ 300 min/wk of MVPA	0.46	0.43	C
5	Sax Institute's 45 and Up study	2016	Australia	MV-LTPA	questionnaire (http://www.45andUp.org.au)	category	HR	0% of MVPA from VPA	1		
	Sax Institute's 45 and Up study	2016	Australia	MV-LTPA	questionnaire (http://www.45andUp.org.au)	category	HR	>0% to <30% of MVPA from VPA	0.89	0.81	0
	Sax Institute's 45 and Up study	2016	Australia	MV-LTPA	questionnaire (http://www.45andUp.org.au)	category	HR	≥30% of MVPA from VPA	0.86	0.79	0
	EPIC - Italy	2016	Italy	LTPA	EPIC lifestyle questionnaire	MET-hr/wk	HR	<73.9	1		
		gend / 🞾	· ·								

#### I Format Painter Clipboard 5

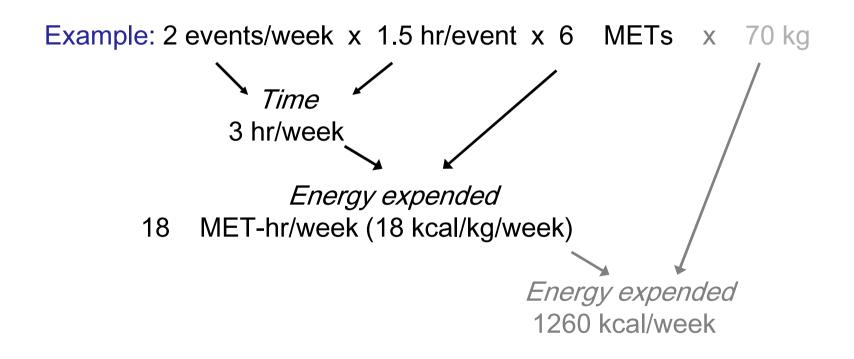
#### **B Z 1 Dose-response Meta-analysis - Motivating Example**

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A	В	С	D	E	F	G	Н		J	
STUDY	YEAR	location	PA DOMAIN	PA MEASUREMENT TOOL	PA Units	EFFECT TYPE	PA CATs	EFFECT SIZE	LCI	U
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		3								
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Danish Nurse Cohort Study	2015	Denmark	LTPA	questionnaire (Saltin and Grimby)	category	HR	Vigorous	1		
Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	Low	1		
Black Women's Health Study	2016	USA	LTPA	questionnaire	ategory	HR	Moderate	1.01	0.64	1
Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	High	0.95	0.4	2
Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	Low	1		
Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	Moderate	0.91	0.55	1
Black Women's Health Study				EE (Marginal-ME			Low Moderate	1	0.87	
,	2016	USA	LTPA	questionnaire	category	HR				1
Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	High	0.85	0.74	0
EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	<45 METs/wk	1		
EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	45–69 METs/wk	1	0.942	1.
EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	69–96 METs/wk	0.998	0.939	1
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EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	<45 METs/wk	1		
EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	45–69 METs/wk	0.983	0.938	1
EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	69–96 METs/wk	0.944	0.899	0
EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	96–134 METs/wk	0.932	0.886	0
EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	134 METs/wk	0.911	0.863	0.
Sax Institute's 45 and Up study	2016	Australia	MV-LTPA	questionnaire (http://www.45andUp.org.au)	mins/wk MVPA	HR	0 - 10 min/wk of MVPA	1		
Sax Institute's 45 and Up study	2016	Australia	MV-LTPA	questionnaire (http://www.45andUp.org.au)	mins/wk MVPA		10 - 149 min/wk of MVPA	0.66	0.61	0
	2016	Australia	MV-LTPA	questionnaire (http://www.45andUp.org.au)	mins/wk MVPA	· · · · ·	150 - 299 min/wk of MVPA	0.53	0.48	0
Sax Institute's 45 and Up study	2016	Australia	MV-LTPA	questionnaire (http://www.45andUp.org.au)	mins/wk MVPA	· · · · ·	≥ 300 min/wk of MVPA	0.46	0.43	0
Sax Institute's 45 and Up study Sax Institute's 45 and Up study				· · · · · · · · · · · · · · · · · · ·						
		Australia	MV-LTPA	questionnaire (http://www.45andUp.org.au)	category	HR	0% of MVPA from VPA	1		
Sax Institute's 45 and Up study Sax Institute's 45 and Up study	2016			and the second sec	category	HR >	0% to <30% of MVPA from /PA	0.89	0.81	0
Sax Institute's 45 and Up study	2016 2016	Australia	MV-LTPA	questionnaire (http://www.45andUp.org.au)						
Sax Institute's 45 and Up study Sax Institute's 45 and Up study			MV-LTPA MV-LTPA	questionnaire (http://www.45andUp.org.au) questionnaire (http://www.45andUp.org.au)	category	HR	≥30% of MVPA from VPA	0.86	0.79	0
Sax Institute's 45 and Up study Sax Institute's 45 and Up study Sax Institute's 45 and Up study	2016	Australia				HR	≥30% of MVPA from VPA	0.86	0.79	(

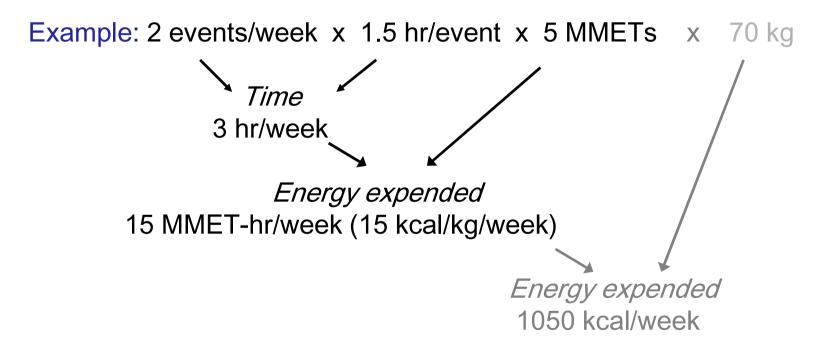
# Computation of estimates of physical activity EE from questionnaires

Frequency x Duration x Intensity x Body weight



# Computation of estimates of physical activity EE from questionnaires

Frequency x Duration x Intensity x Body weight



Can we work this out from aggregate data?

## Mapping aggregate MET.hours to MMET.hours

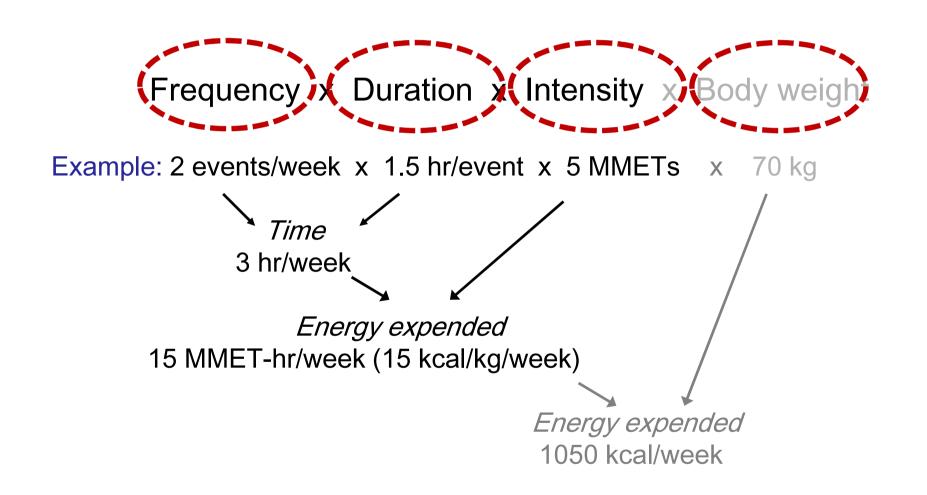
Mean MET.hrs by exposure group

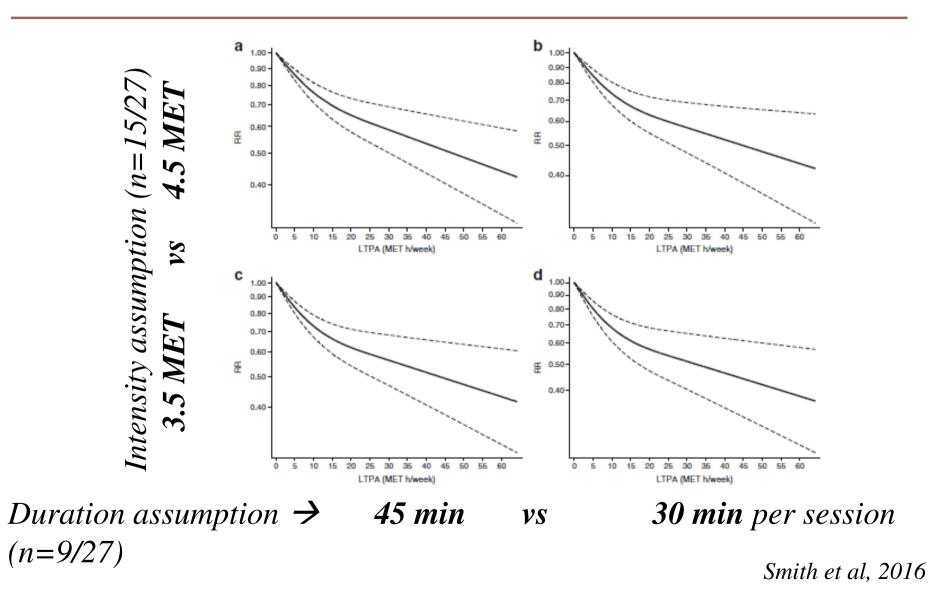
REE component is 1 MET per reported hour

Is mean duration reported by exposure group?

- MMET.hrs = MET.hrs 1 MET x duration (hrs)
- Mean duration not available?
  - Make assumption about duration
  - Use relationship between MMET.hrs and MET.hrs in other selfreport data where it both are available
    - e.g. MMET.hrs =  $b_1^*$  MET.hrs +  $b_2^*$  MET.hrs<sup>2</sup>

Any of these not measured (reported)?





	(Du	-	physical activity and cycling in hrs	s/wk)
Work activity	No	≤3.5	>3.5 and ≤7.0	> 7.0
		Moderately	Moderately	
Sedentary	Inactive	inactive	active	Active
	Moderately	Moderately		
Standing	inactive	active	Active	Active
	Moderately			
Manual	active	Active	Active	Active
Heavy manual	Active	Active	Active	Active

(InterAct Consortium, Eur J Epid, 2012)

## How do we map this exposure to PAEE?

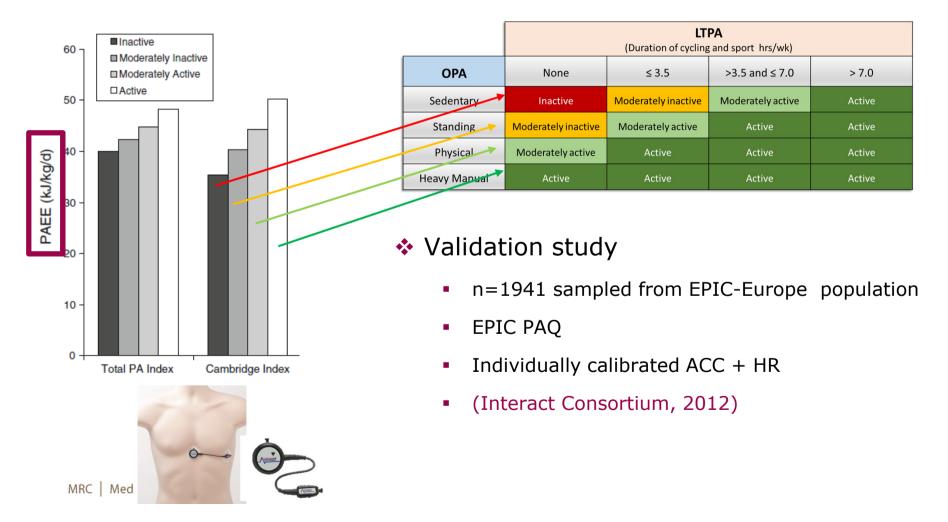
		Leisure time	physical activity			
	(Du	ration of sport a	and cycling in hrs	/wk)		$\frown$
Work activity	No	≤3.5	>3.5 and ≤7.0	> 7.0		
		Moderately	Moderately		<b>`</b>	
Sedentary	Inactive	inactive	active	Active		
	Moderately	Moderately				
Standing	inactive	active	Active	Active		
	Moderately					
Manual	active	Active	Active	Active		
Heavy manual	Active	Active	Active	Active		

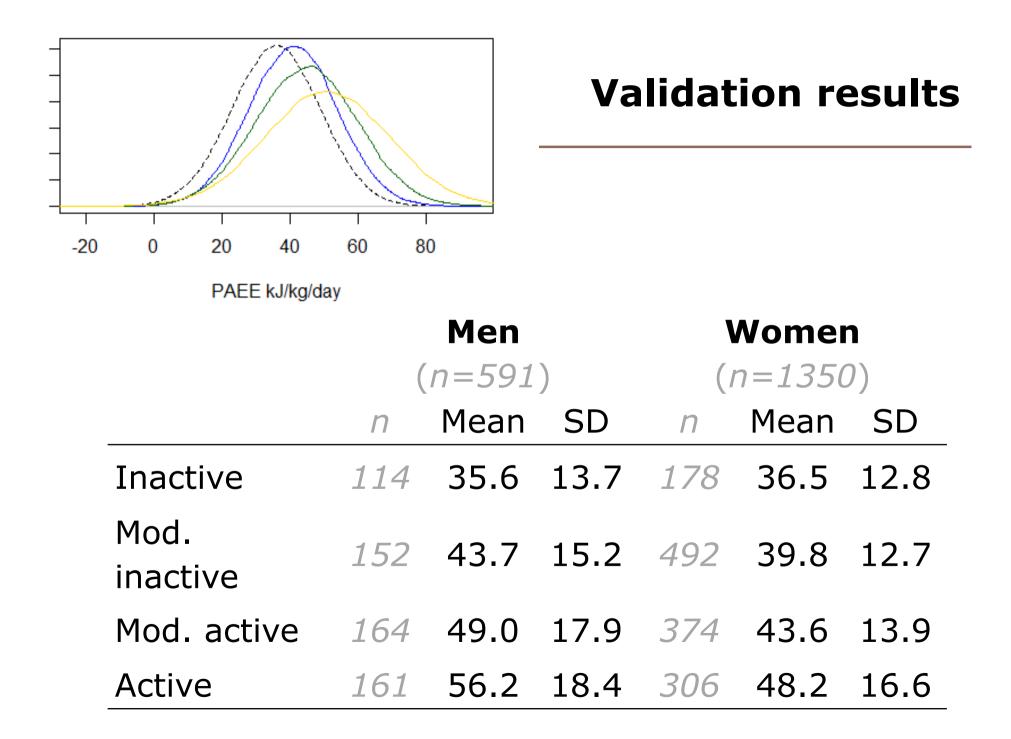
- 2-level index
- 4-level index
- 16-level index

PAEE

## Validation study: Obj assessment of PA

Combined PA Index (Occupational & Leisure-time PA)

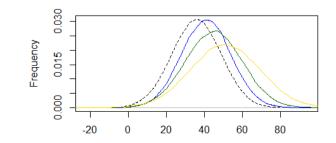




## Analysis example: PAEE association with diabetes



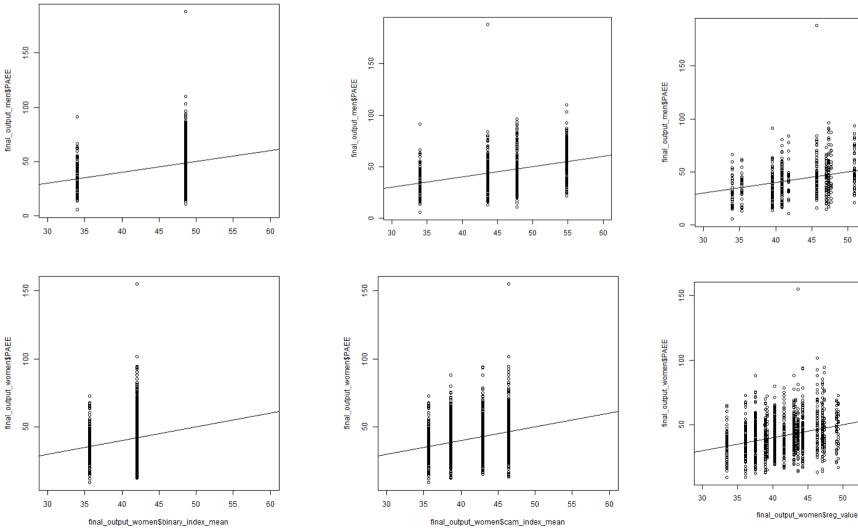
- Simulate **3 different self-report methods**:
  - **A. Binary** inactive/active  $\rightarrow \rightarrow \rightarrow$  **PAEE** from validation
  - **B.** 4-level PA index  $\rightarrow \rightarrow \rightarrow$  **PAEE** from validation
  - **C. 16-level** PA index  $\rightarrow \rightarrow \rightarrow$  **PAEE** from validation
- Cox regression to model harmonised PAEE-T2DM association for each method in each InterAct cohort
- Meta-analysis across cohorts



## **Exposure mapping**

	(Du		physical activity and cycling in hrs	:/wk)
Work activity	No	≤3.5	>3.5 and ≤7.0	> 7.0
		Moderately	Moderately	
Sedentary	Inactive	inactive	active	Active
	Moderately	Moderately		
Standing	inactive	active	Active	Active
	Moderately			
Manual	active	Active	Active	Active
Heavy manual	Active	Active	Active	Active

#### A. Binary



**B.** 4-level index

C. 16-level index

# Association between PAEE and T2DM (men)

B. 4-level index

A. Binary

Cam Index - Men Binary Index - Men Regression values - Men Hazard ratio [95% CI] Hazard ratio [95% CI] Hazard ratio [95% CI] ITAL Y 1.001 [ 0.971 , 1.031 ] ITALY 1.000 [ 0.976 . 1.025 ] ITAL Y 0 999 [ 0 978 1 022 ] ----0.989 [ 0.977 , 1.002 ] ----SPAIN 0.991[0.976.1.006] SPAIN 0.990 [ 0.976 , 1.005 ] SPAIN -----UK 0.986 [ 0.962 , 1.011 ] UK 0.986 [ 0.963 , 1.009 ] UK 0.984 [ 0.960 , 1.009 ] NETHERLANDS 1 014 [ 0 975 1 055 ] NETHERLANDS 1.004 [ 0.975 , 1.035 ] NETHERLANDS 0.990 [ 0.966 , 1.014 ] GERMANY 0.958 [ 0.938 . 0.979 ] GERMANY 0.95510.937.0.9731 GERMANY 0.956 [ 0.936 , 0.976 ] SWEDEN -0 981 [ 0 966 0 997 ] SWEDEN 0 978 [ 0 963 0 993 ] SWEDEN 0.987 [ 0.972 , 1.002 ] -----DENMARK DENMARK ------0.987 [ 0.967 , 1.008 ] DENMARK -0.982 [ 0.967 , 0.997 ] 0.980 [ 0.967 , 0.994 ] Overall (l<sup>2</sup> = 43%, p = 0.107) 0.985 [ 0.975 , 0.996 ] Overall (1<sup>2</sup> = 59%, p = 0.025) 0.983 [ 0.972 , 0.994 ] Overall (l<sup>2</sup> = 45%, p = 0.093) 0.984 [ 0.975 , 0.993 ] 0.905 0.951 1.000 1.051 1.105 0.923 0.961 1.000 1.041 0.923 0.942 0.961 0.980 1.000 1.020 1.041 Test of H<sub>a</sub>; true hazard ratio = 1, p = 0.006 Test of H<sub>0</sub>: true hazard ratio = 1, p = 0.002 Test of H<sub>0</sub>: true hazard ratio = 1, p = 0.001 **Method** B Α С HR per 1kj 0.985 0.983 0.984 HR per 10kj 0.860 0.842 0.851 P-value 0.006 0.002 0.001

C. 16-level index

# Association between PAEE and T2DM (women)

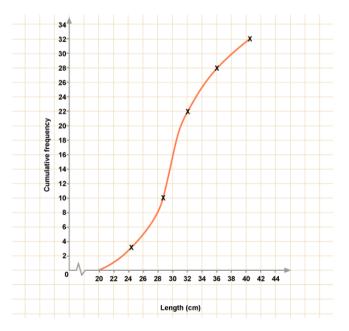
**B.** 4-level index

A. Binary

Binary Index - women Cam Index - women Regression values - women Hazard ratio [95% CI] Hazard ratio [95% CI] Hazard ratio [95% CI] FRANCE 0.97210.898 1.0521 ERANCE 0.977 [ 0.924 . 1.033 ] FRANCE 0.976 [ 0.925 , 1.029 ] ITALY 0.969[0.929.1.010] ITAL Y 0.975 [ 0.939 , 1.012 ] ITAL Y 0.975 [ 0.940 , 1.012 ] SPAIN . 1.016 [ 0.989 , 1.044 ] SPAIN 1.004 [ 0.975 , 1.034 ] SPAIN 1.004 [ 0.980 , 1.027 ] UК 0.94510.892 1.0011 0.962 [ 0.909 , 1.019 ] - HK UK 0.957 [ 0.909 , 1.008 ] NETHERLANDS 0.902[0.851.0.955] NETHERLANDS 0.959 [ 0.929 , 0.989 ] \_\_\_\_ NETHERLANDS 0.941 [ 0.915 , 0.968 ] **\_\_\_\_** GERMANY 0.962 [ 0.913 , 1.014 ] GERMANY 0.984 [ 0.949 , 1.020 ] GERMANY 0.976 [ 0.943 , 1.010 ] SWEDEN -----0.980[0.947.1.014] SWEDEN -0.989 [ 0.962 , 1.018 ] SWEDEN 0.979 [ 0.953 , 1.005 ] -----DENMARK \_\_\_\_ 0.972 [ 0.920 , 1.028 ] DENMARK 0.975 [ 0.948 , 1.003 ] DENMARK 0.973 [ 0.947 , 1.001 ] -Overall (l<sup>2</sup> = 59%, p = 0.016) 0.969 [ 0.944 , 0.994 ] Overall (I<sup>2</sup> = 0%, p = 0.576) 0.981 [ 0.969 , 0.993 ] Overall ( $l^2 = 44\%$ , p = 0.082) 0.974[0.959.0.989] 0.819 0.861 0.905 0.951 1.000 1.051 1.105 0.905 0.951 1.000 1.051 0.951 1.000 0.905 1.051 Test of H<sub>n</sub>: true hazard ratio = 1, p = 0.016 Test of H<sub>a</sub>: true hazard ratio = 1 p = 0.002 Test of H<sub>a</sub>; true hazard ratio = 1, p = 0.001 **Method** B Α С HR per 1kj 0.969 0.981 0.974 HR per 10kj 0.730 0.825 0.768 P-value 0.016 0.002 0.001

C. 16-level index

# Marginalisation, validation, interpolation



MRC | Medical Research Council

## Paste Copy\* Paste Format Painter B I 1 Dose-response Meta-analysis - Motivating Example

			Evno	sure Harmonisatio	n• Mata	-data		E	diting	
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STUDY	B YEAR	location	PA DOMAIN	PA MEASUREMENT TOOL	PA Units	EFFECT TYPE		EFFECT SIZE	LCI	
EPIC-Europe	2015	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	<45 METs/wk	1		
EPIC-Europe	2015	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	45-69 METs/wk	0.97	0.91	
EPIC-Europe	2015	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	69-96 METs/wk	0.94	0.89	
EPIC-Europe	2015	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	96-134 METs/wk	0.9	0.83	
EPIC-Europe	2015	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	134 METs/wk	0.87	0.8	
Danish Nurse Cohort Study	2015	Denmark	LTPA	questionnaire (thin and Grimby)	category	HR	Sedentary	1.62	1.15	
Danish Nurse Cohort Study	2015	Denmark	LTPA	questionnaire ( Itin and Grimby)	category	HR	Moderate	1.1	0.91	
Danish M						un	Vigorous	1		
	F۵	nosu	re Calibratio	on - using Objective Val	lidation 9	Study -	•			
Eur J Epidemiol (2012) 27	:13-2:	Posu					Low	1		
DOI 10.1007/s10654-011-9	025-y							1.01	0.64	_
METHODS								0.95	0.4	-
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	ale and any			ical activity				0.91	0.55	
			ire to assess phys					0.58	0.22	
in 10 Europea	an count	ries			and the second se					
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Bla The InterAct Consort	ium			Actilieart				0.98	0.87	
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Received: 16 August 2011	/ Accepted: 7 Oc	ctober 2011/Pub	lished online: 17 November 2011		Actineant of		-	0.998	0.939	
© The Author(s) 2011. Th	is article is publi	ished with open a	access at Springerlink.com				-			
							-	0.987	0.926	
Abstract To accurate	•			%, $P < 0.05$ , $I^2 > 47\%$ , $P < 0.05$ ). PAEE				1		
activity (PA) with dis assessing free-living a		.,		y across self-reported PA categories (P for			-	0.983	0.938	-
the validity of a brief	•			and 365 kJ/d for women, between cat				0.983	0.938	
		~		and the second s	MET quintiles	HR	96–134 METs/wk	0.934	0.886	
	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	134 METs/wk	0.952	0.863	
EPIC-Europe		Lurope	ETFA (plus household)	Leto mestyle questionnalle	wich quintiles	IIN	134 IVIETS/ WK	0.911	0.005	
EPIC-Europe	2010	1			and an Andrea All An All An	HR	0 - 10 min/wk of MVPA	1		
	2016	Australia	MV-LTPA	questionnaire (http://www.45andUp.org.au)	mins/wk MVPA			-		
ax Institute's 45 and Up study		Australia Australia	MV-LTPA MV-LTPA	questionnaire (http://www.45andUp.org.au) questionnaire (http://www.45andUp.org.au)	mins/wk MVPA mins/wk MVPA	HR	10 - 149 min/wk of MVPA	0.66	0.61	
ax Institute's 45 and Up study ax Institute's 45 and Up study	2016					HR			0.61 0.48	
ax Institute's 45 and Up study ax Institute's 45 and Up study ax Institute's 45 and Up study	2016 2016	Australia	MV-LTPA	questionnaire (http://www.45andUp.org.au)	mins/wk MVPA	HR	10 - 149 min/wk of MVPA	0.66		
ax Institute's 45 and Up study ax Institute's 45 and Up study ax Institute's 45 and Up study ax Institute's 45 and Up study	2016 2016 2016 2016	Australia Australia Australia	MV-LTPA MV-LTPA MV-LTPA	questionnaire (http://www.45andUp.org.au) questionnaire (http://www.45andUp.org.au) questionnaire (http://www.45andUp.org.au)	mins/wk MVPA mins/wk MVPA mins/wk MVPA	HR HR	10 - 149 min/wk of MVPA 150 - 299 min/wk of MVPA ≥ 300 min/wk of MVPA	0.66 0.53 0.46	0.48	
ax Institute's 45 and Up study ax Institute's 45 and Up study	2016 2016 2016 2016 2016	Australia Australia Australia Australia	MV-LTPA MV-LTPA MV-LTPA MV-LTPA	questionnaire (http://www.45andUp.org.au) questionnaire (http://www.45andUp.org.au) questionnaire (http://www.45andUp.org.au) questionnaire (http://www.45andUp.org.au)	mins/wk MVPA mins/wk MVPA mins/wk MVPA category	HR HR HR	10 - 149 min/wk of MVPA 150 - 299 min/wk of MVPA ≥ 300 min/wk of MVPA 0% of MVPA from VPA	0.66 0.53 0.46 1	0.48 0.43	
ax Institute's 45 and Up study ax Institute's 45 and Up study	2016 2016 2016 2016 2016 2016 2016	Australia Australia Australia Australia Australia	MV-LTPA MV-LTPA MV-LTPA MV-LTPA MV-LTPA	questionnaire (http://www.45andUp.org.au) questionnaire (http://www.45andUp.org.au) questionnaire (http://www.45andUp.org.au) questionnaire (http://www.45andUp.org.au) questionnaire (http://www.45andUp.org.au)	mins/wk MVPA mins/wk MVPA mins/wk MVPA category category	HR HR HR HR	10 - 149 min/wk of MVPA 150 - 299 min/wk of MVPA ≥ 300 min/wk of MVPA 0% of MVPA from VPA >0% to <30% of MVPA from VPA	0.66 0.53 0.46 1 0.89	0.48 0.43 0.81	
ax Institute's 45 and Up study ax Institute's 45 and Up study	2016 2016 2016 2016 2016	Australia Australia Australia Australia	MV-LTPA MV-LTPA MV-LTPA MV-LTPA	questionnaire (http://www.45andUp.org.au) questionnaire (http://www.45andUp.org.au) questionnaire (http://www.45andUp.org.au) questionnaire (http://www.45andUp.org.au)	mins/wk MVPA mins/wk MVPA mins/wk MVPA category	HR HR HR	10 - 149 min/wk of MVPA 150 - 299 min/wk of MVPA ≥ 300 min/wk of MVPA 0% of MVPA from VPA	0.66 0.53 0.46 1	0.48 0.43	
ax Institute's 45 and Up study ax Institute's 45 and Up study	2016 2016 2016 2016 2016 2016 2016	Australia Australia Australia Australia Australia	MV-LTPA MV-LTPA MV-LTPA MV-LTPA MV-LTPA	questionnaire (http://www.45andUp.org.au) questionnaire (http://www.45andUp.org.au) questionnaire (http://www.45andUp.org.au) questionnaire (http://www.45andUp.org.au) questionnaire (http://www.45andUp.org.au)	mins/wk MVPA mins/wk MVPA mins/wk MVPA category category	HR HR HR HR	10 - 149 min/wk of MVPA 150 - 299 min/wk of MVPA ≥ 300 min/wk of MVPA 0% of MVPA from VPA >0% to <30% of MVPA from VPA	0.66 0.53 0.46 1 0.89	0.48 0.43 0.81	

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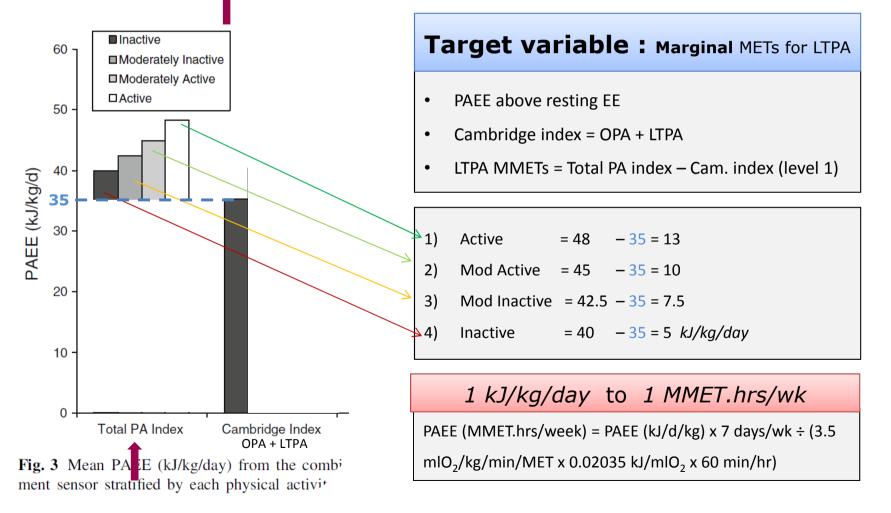
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#### **B Z 1 Dose-response Meta-analysis -** Motivating Example

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Exposure Calibration: using Objective Validation Study

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	STUDY	YEAR	location	PA DOMAIN	PA MEASUREMENT TOOL	PA Units	EFFECT TYPE	PA CATs	EFFECT SIZE	LCI	UCI
	EPIC-Europe	2015	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	<45 METs/wk	1		
	EPIC-Europe	2015	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	45-69 METs/wk	0.97	0.91	1.04
	EPIC-Europe	2015	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	69-96 METs/wk	0.94	0.89	1.02
	EPIC-Europe	2015	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	96-134 METs/wk	0.9	0.83	0.97
	EPIC-Europe	2015	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	134 METs/wk	0.87	0.8	0.95



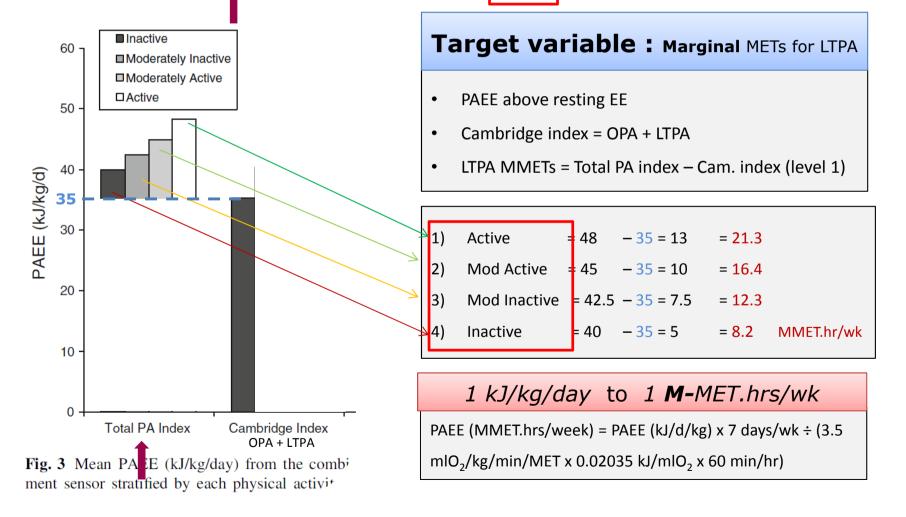
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#### **B Z 1 Dose-response Meta-analysis -** Motivating Example

Exposure Calibration: using Objective Validation Study

A	В	C	D	E	F	G	Н	1	J	K
STUDY	YEAR	location	PA DOMAIN	PA MEASUREMENT TOOL	PA Units	EFFECT TYPE	PA CATs	EFFECT SIZE	LCI	UCI
EPIC-Europe	2015	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	<45 METs/wk	1		
EPIC-Europe	2015	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	45-69 METs/wk	0.97	0.91	1.04
EPIC-Europe	2015	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	69–96 METs/wk	0.94	0.89	1.02
EPIC-Europe	2015	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	96-134 METs/wk	0.9	0.83	0.97
EPIC-Europe	2015	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	134 METs/wk	0.87	0.8	0.95



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#### **B Z 1 Dose-response Meta-analysis -** Motivating Example

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	EPIC-Europe	2015	Europe	LTPA (plus household)	EDIC lifest	yle questionnair	MET quintiles	HR	<45 METs/wk	1		
	EPIC-Europe	2015		LTPA (plus household)		yle questionnaire			45–69 METs/wk	0.97	0.91	1.04
	EPIC-Europe	2015		LTPA (plus household)		yle questionnair			69–96 METs/wk	0.94	0.89	1.0
	EPIC-Europe	2015		LTPA (plus household)		yle questionnair			96-134 METs/wk	0.9	0.83	0.9
	EPIC-Europe	2015		LTPA (plus household)		yle questionnair			134 METs/wk	0.87	0.8	0.9
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#### **B Z** 1 **Dose-response Meta-analysis - Motivating Example**

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3 4	EPIC-Europe	2015	Europe		household)	EPIC lifestyle questionnaire		MET quintiles MET quintiles	HR HR	<45 METs/wk 45–69 METs/wk 11	1	0.91	1.04
5	EPIC-Europe EPIC-Europe	2015	Europe Europe		household) household)	EPIC lifestyle questionnaire EPIC lifestyle questionnaire		MET quintiles	HR	69–96 METs/wk 14	0.57	0.91	1.04
6	EPIC-Europe	2015	Europe		household)		yle questionnaire	MET quintiles	HR	96-134 METs/wk 18		0.83	0.97
7	EPIC-Europe	2015	Europe		household)	EPIC lifestyle questionnaire		MET quintiles	HR	134 METs/wk 21		0.8	0.95
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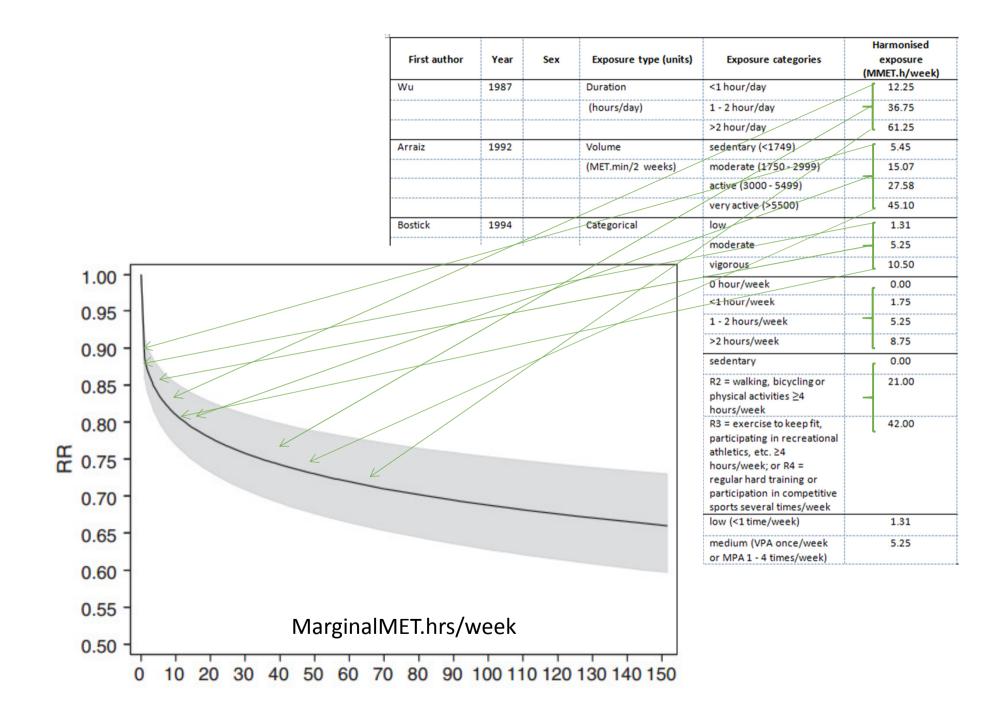
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#### **B Z 1 Dose-response Meta-analysis -** Motivating Example

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#### Exposure Harmonisation: Meta-data

	A	В	С	D	E	F	G	Н	1	J	
	STUDY	YEAR	location	PA DOMAIN	PA MEASUREMENT TOOL	PA Units	EFFECT TYPE	PA CATs	EFFECT SIZE	LCI	ι
	EPIC-Europe	2015	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	<45 METs/wk 7.6	1		
	EPIC-Europe	2015	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	45-69 METs/wk 11.1	0.97	0.91	0
	EPIC-Europe	2015	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	69-96 METs/wk 14.5		0.89	
	EPIC-Europe	2015	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	96-134 METs/wk 18.0		0.83	
	EPIC-Europe	2015	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	134 METs/wk 21.5		0.8	
F	Danish Nurse Cohort Study	2015	Denmark	LTPA	questionnaire (Saltin and Grimby)	category	HR	Sedentary	1.62	1.15	
ŀ	Danish Nurse Cohort Study	2015	Denmark	LTPA	questionnaire (Saltin and Grimby)	category	HR	Moderate	1.1	0.91	
ŀ	Danish Nurse Cohort Study	2015	Denmark	LTPA	questionnaire (Saltin and Grimby)	category	HR	Vigorous	1		
E	Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	Low	1		-
	lack Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	Moderate	1.01	0.64	
	Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	High	0.95	0.4	
E	Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	Low	1		-
E	lack Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	Moderate	0.91	0.55	
-	Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	High	0.58	0.22	
	Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	Low	1		
	lack Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	Moderate	0.98	0.87	
E	Black Women's Health Study	2016	USA	LTPA	questionnaire	category	HR	High	0.85	0.74	
ŀ	EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	<45 METs/wk	1		-
	EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	45-69 METs/wk	1	0.942	1
	EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	69–96 METs/wk	0.998	0.939	1
	EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	96-134 METs/wk	0.993	0.934	1
	EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	134 METs/wk	0.987	0.926	:
	EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	<45 METs/wk	1		
	EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	45–69 METs/wk	0.983	0.938	1
	EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	69–96 METs/wk	0.944	0.899	
	EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	96–134 METs/wk	0.932	0.886	
	EPIC-Europe	2016	Europe	LTPA (plus household)	EPIC lifestyle questionnaire	MET quintiles	HR	134 METs/wk	0.911	0.863	(
	x Institute's 45 and Up study	2016	Australia	MV-LTPA	questionnaire (http://www.45andUp.org.au)	mins/wk MVPA	HR	0 - 10 min/wk of MVPA	1		
	ax Institute's 45 and Up study	2016	Australia	MV-LTPA	questionnaire (http://www.45andUp.org.au)	mins/wk MVPA		10 - 149 min/wk of MVPA	0.66	0.61	
	ax Institute's 45 and Up study	2016	Australia	MV-LTPA	questionnaire (http://www.45andUp.org.au)	mins/wk MVPA	HR	150 - 299 min/wk of MVPA	0.53	0.48	
	x Institute's 45 and Up study	2016	Australia	MV-LTPA	questionnaire (http://www.45andUp.org.au)	mins/wk MVPA	HR	≥ 300 min/wk of MVPA	0.46	0.43	
	x Institute's 45 and Up study	2016	Australia	MV-LTPA	questionnaire (http://www.45andUp.org.au)	category	HR	0% of MVPA from VPA	1		
ŀ	x Institute's 45 and Up study	2016	Australia	MV-LTPA	questionnaire (http://www.45andUp.org.au)	category	HR	>0% to <30% of MVPA from VPA	0.89	0.81	
	x Institute's 45 and Up study	2016	Australia	MV-LTPA	questionnaire (http://www.45andUp.org.au)	category	HR	≥30% of MVPA from VPA	0.86	0.79	
	EPIC - Italy	2016	Italy	LTPA	EPIC lifestyle questionnaire	MET-hr/wk	HR	<73.9	1		

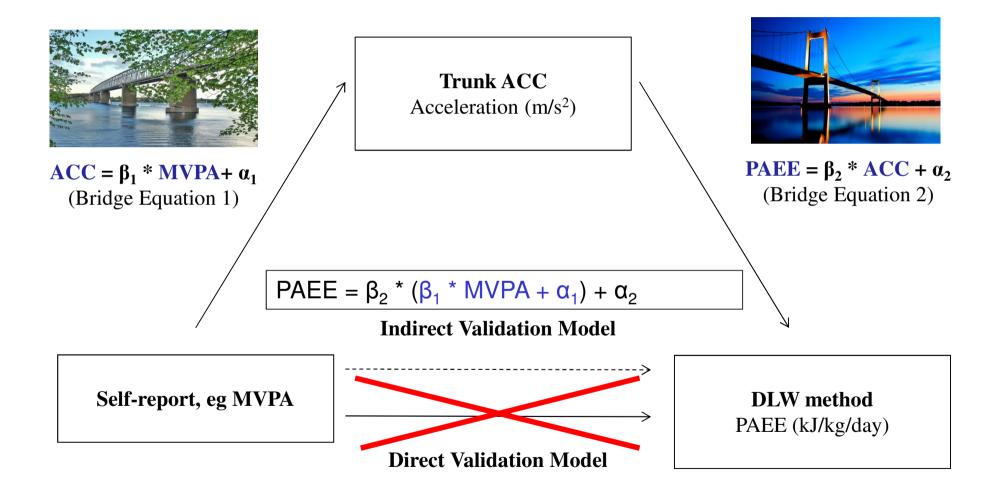


# Indirect validation



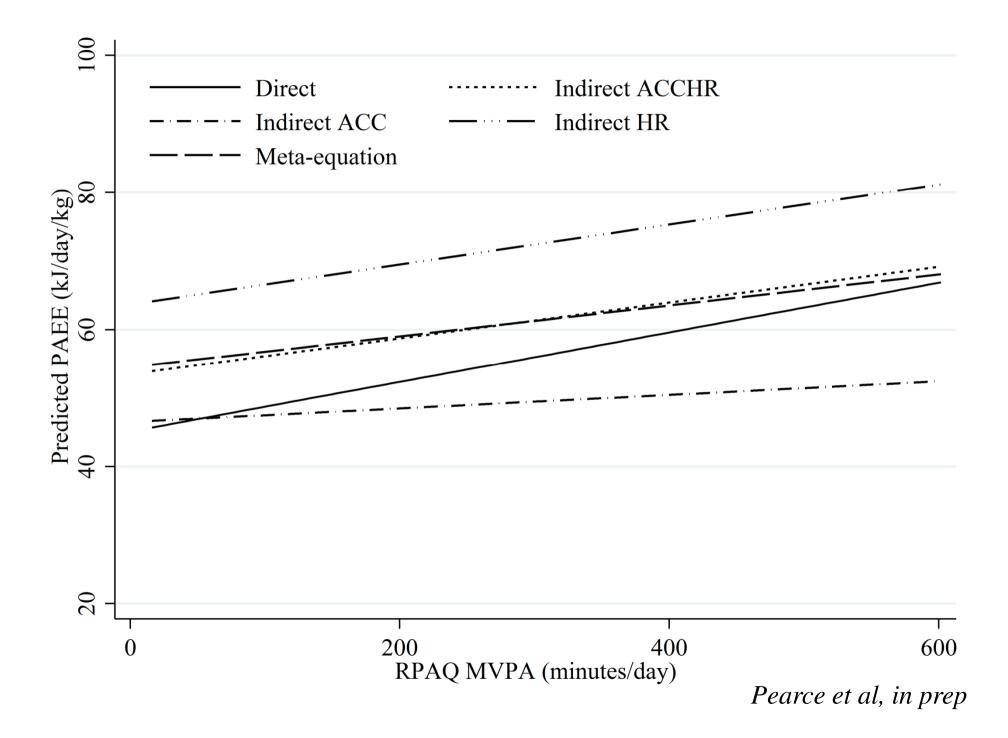
MRC | Medical Research Council

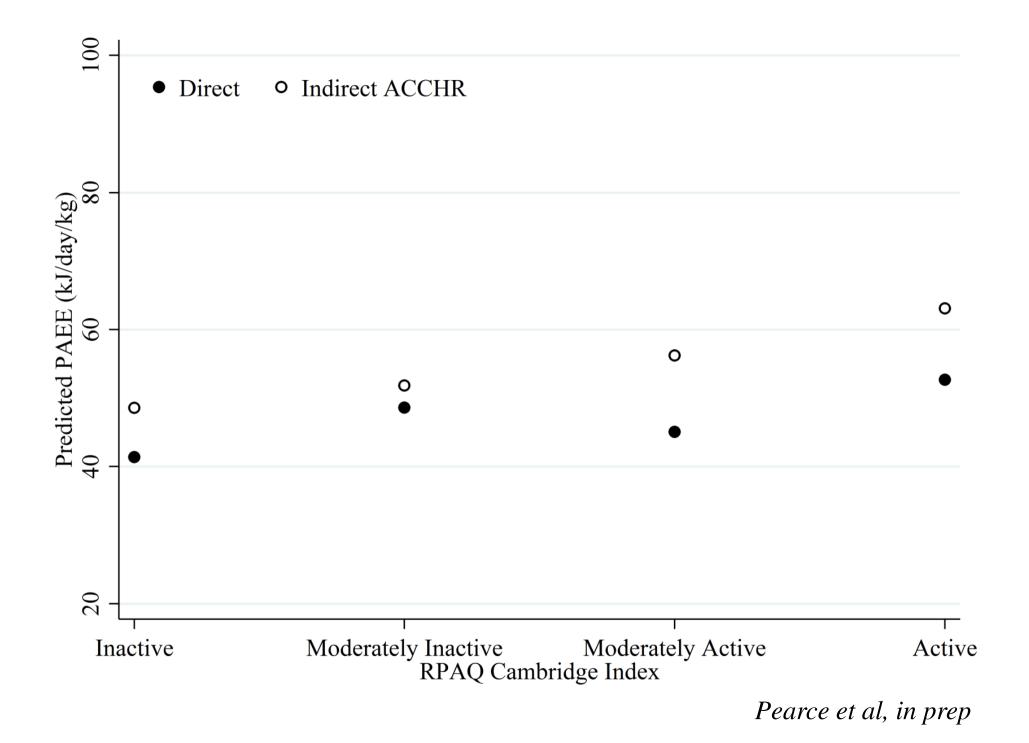
### Harmonisation in absence of direct validation

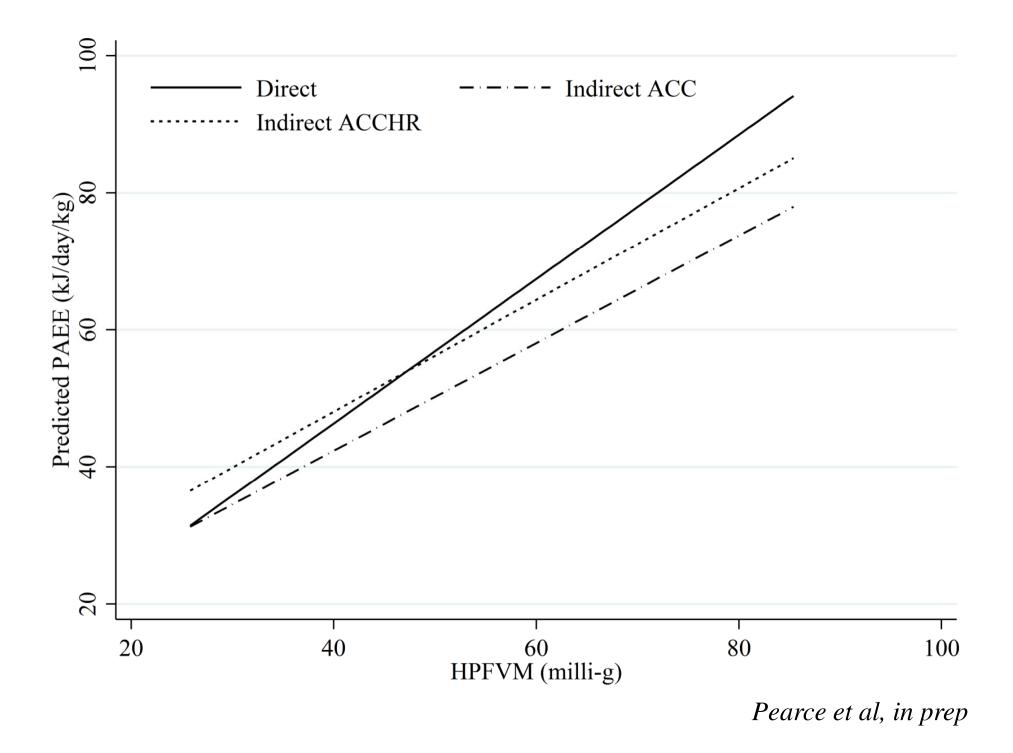


# Bridge equations

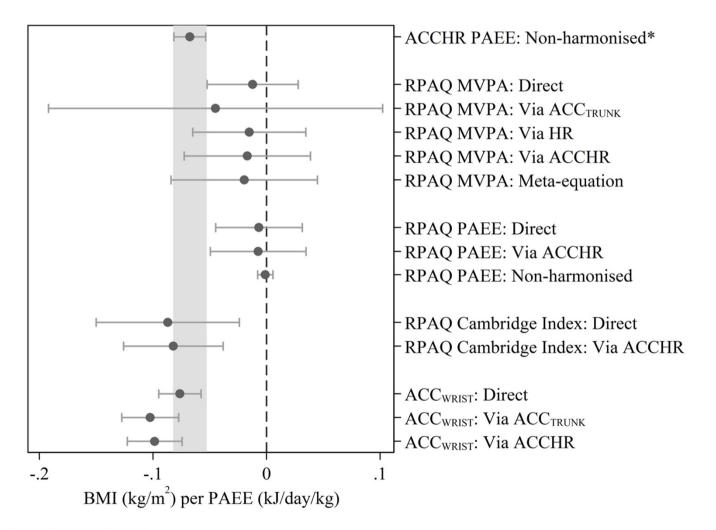
Bridge	Starting	Intermediate	Target	N (	β(SE)	$(\alpha (SE)) r^2$	
	Variable	Variable	Variable				
Indirect harmonisati	on of RPAQ MVPA via ACC <sub>TRUNK</sub>						
AC	RPAQ MVPA (minutes•day-1)	ACC <sub>TRUNK</sub> (m•s <sup>-2</sup> )	-	2121	$5.84 \cdot 10^{-5} (7.9 \cdot 10^{-6})$	.1199 (.0015)	.02
CB	-	ACC <sub>TRUNK</sub> (m•s <sup>-2</sup> )	DLW PAEE (kJ•day <sup>-1</sup> •kg <sup>-1</sup> )	46	165 (32)	26.7 (8.2)	.37
Indirect harmonisati	on of RPAQ MVPA via PAEE from HR						
AC	RPAQ MVPA (minutes•day-1)	HR PAEE (kJ•day <sup>-1</sup> •kg <sup>-1</sup> )	-	2121	.0840 (.0061)	60.9 (1.2)	.08
CB		HR PAEE (kJ•day <sup>-1</sup> •kg <sup>-1</sup> )	DLW PAEE (kJ•day <sup>-1</sup> •kg <sup>-1</sup> )	46	.34 (.07)	42.7 (5.8)	.34
Indirect harmonisati	on of RPAQ MVPA via PAEE from ACCHI	R					
AC	RPAQ MVPA (minutes•day <sup>-1</sup> )	ACCHR PAEE (kJ•day <sup>-1</sup> •kg <sup>-1</sup> )	-	2120	.0390 (.0030)	50.69 (.57)	.07
СВ	-	ACCHR PAEE (kJ•day <sup>-1</sup> •kg <sup>-1</sup> )	DLW PAEE (kJ•day <sup>-1</sup> •kg <sup>-1</sup> )	46	.66 (.11)	20.0 (8.1)	.45
Indirect harmonisati	on of RPAQ PAEE via PAEE from ACCHR	2					
AC	RPAQ PAEE (kJ•day <sup>-1</sup> •kg <sup>-1</sup> )	ACCHR PAEE (kJ•day <sup>-1</sup> •kg <sup>-1</sup> )	-	2120	.239 (.014)	45.63 (.69)	.12
СВ		ACCHR PAEE (kJ•day <sup>-1</sup> •kg <sup>-1</sup> )	DLW PAEE (kJ•day <sup>-1</sup> •kg <sup>-1</sup> )	46	.66 (.11)	20.0 (8.1)	.45
Indirect harmonisati	on of Cambridge Index via PAEE from AC	CHR					
AC	RPAQ Cambridge Index	ACCHR PAEE (kJ•day <sup>-1</sup> •kg <sup>-1</sup> )	-	2120	*Inactive =0; Moderately inactive = 4.5 (2.6); Moderately active = 11.1 (2.6); Active = 21.5 (2.6)	42.9 (2.5)	.11
СВ		ACCHR PAEE (kJ•day <sup>-1</sup> •kg <sup>-1</sup> )	DLW PAEE (kJ•day <sup>-1</sup> •kg <sup>-1</sup> )	46	.66 (.11)	20.0 (8.1)	.45
Indirect harmonisati	on of ACC <sub>WRIST</sub> via ACC <sub>TRUNK</sub>						
AC	ACC <sub>WRIST</sub> (milli-g)	ACC <sub>TRUNK</sub> (m•s <sup>-2</sup> )	-	1050	$.4.78 \cdot 10^{-3} (9.0 \cdot 10^{-5})$	097 (.0036)	.53
СВ		ACC <sub>TRUNK</sub> (m•s <sup>-2</sup> )	DLW PAEE (kJ•day <sup>-1</sup> •kg <sup>-1</sup> )	46	165 (32)	26.7 (8.2)	.37
Indirect harmonisati	on of ACC <sub>WRIST</sub> via PAEE from ACCHR						
AC	ACC <sub>WRIST</sub> (milli-g)	ACCHR PAEE (kJ•day-1•kg-1)	-	1050	1.232 (.012		
СВ		ACCHR PAEE (kJ•day <sup>-1</sup> •kg <sup>-1</sup> )	DLW PAEE (kJ•day <sup>-1</sup> •kg <sup>-1</sup> )	46	.66 (.11) <i>Pearce</i>	et al, in	pre







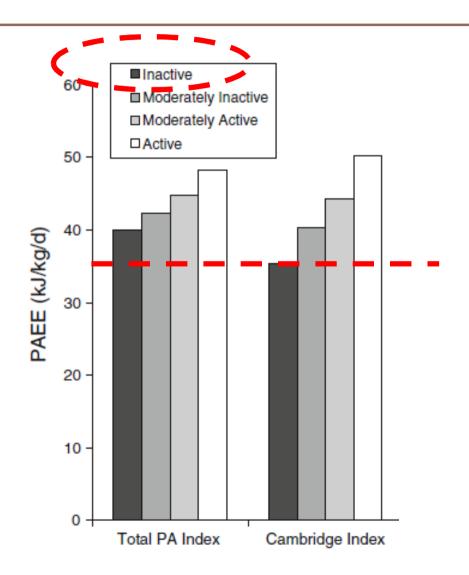
## Inferentially equivalent? Association with BMI



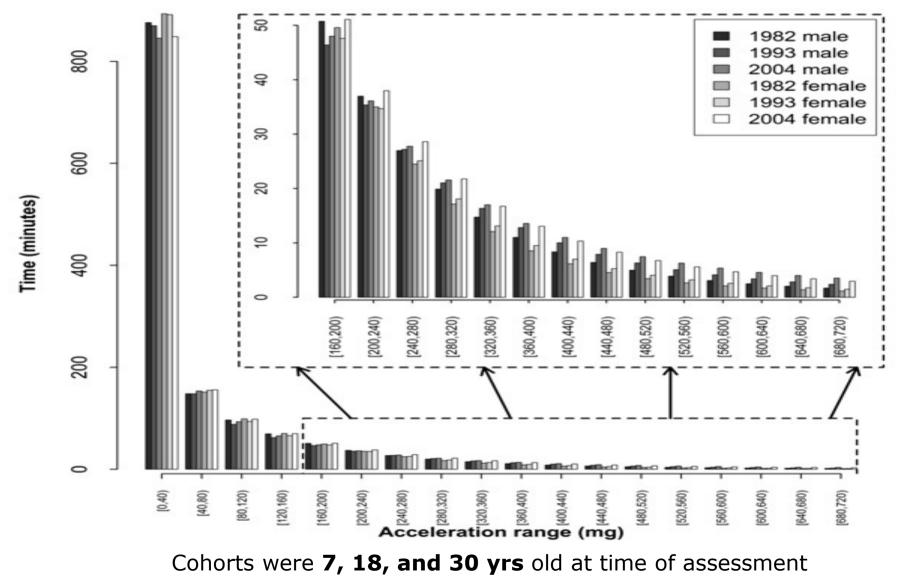
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Pearce et al, in prep

Absolute versus marginalised mapping...



### Other target variables: Movement intensity distributions



da Silva et al, IJE 2014



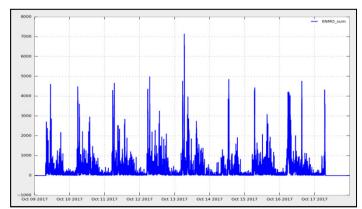
World Health Organization

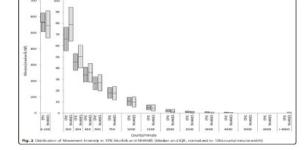
## Large cohorts and surveillance e.g. UKBB, WHO STEPS?









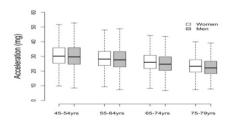


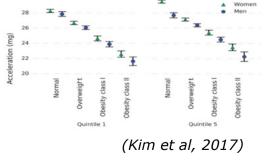
(Berkemeyer et al, 2016; Yerrakalva et al, 2017; Hajna et al, 2018)

biobank

EPIC

n~100k



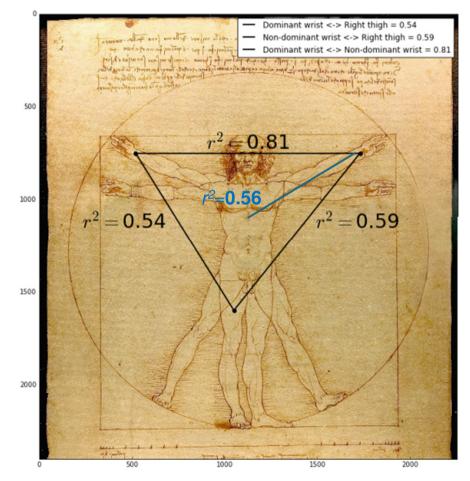


(Doherty et al, 2017)

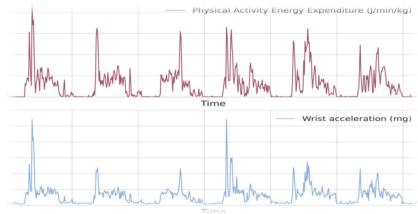
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### What should be the criterion measure for movement?

Segment vs whole-body movement?



### Segment vs whole-body PAEE? Within-id vs between-id?



White et al, 2016+2018

## Discoverability of method relationships

- Published peer-reviewed papers
- Published papers, eg BioRxiv
- Share bridge equations and metadata
- Share raw data
- What format?
- Who will host (fund)?
- Who will contribute?
- How to make that attractive?





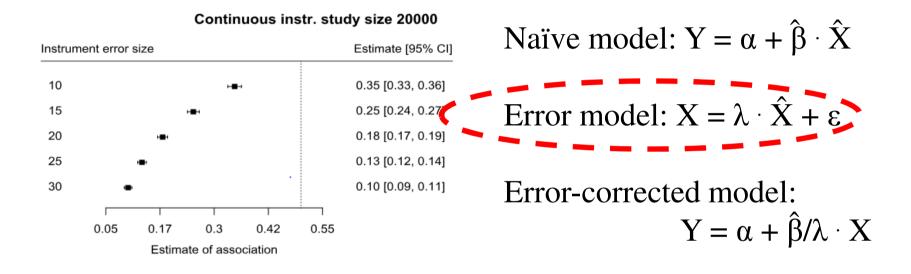




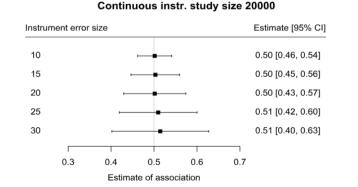
### Relation to measurement error correction

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### Imagine a study with true association = 0.5



#### Using validation study with... **n=400**



#### and... **n=1600**

Continuous instr. study size 20000 Instrument error size Estimate [95% CI] 10 0.50 [0.48, 0.53] 15 0.50 [0.47, 0.54] 20 0.51 [0.46, 0.55] 25 0.51 [0.46, 0.57] 30 0.51 [0.44, 0.57] 0.3 0.4 0.5 0.6 0.7 Estimate of association

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Bishop et al, in prep

### Conclusion

- Multiple ways of **connecting** data help harmonisation
- Marginalisation is a (blunt!) tool
- Some **assumptions** needed, most are testable
- Mapping to latent variable by use of validation data is a viable alternative to classic harmonisation
  - Inclusive: Allows ALL data sources to be integrated
  - Implicitly quantifies **uncertainty** of the process
- Achieves **inferential equivalence** in downstream analyses?
- Harmonisation using indirect validation is a viable alternative to direct validation
  - **Narrows** the **range** of harmonised values compared with DLW
- **Population specificity** an issue
- Further work:
  - Full integration with **measurement error correction** techniques

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