



# Escalator experiment

VÄSTRA SKOGEN - STOCKHOLM



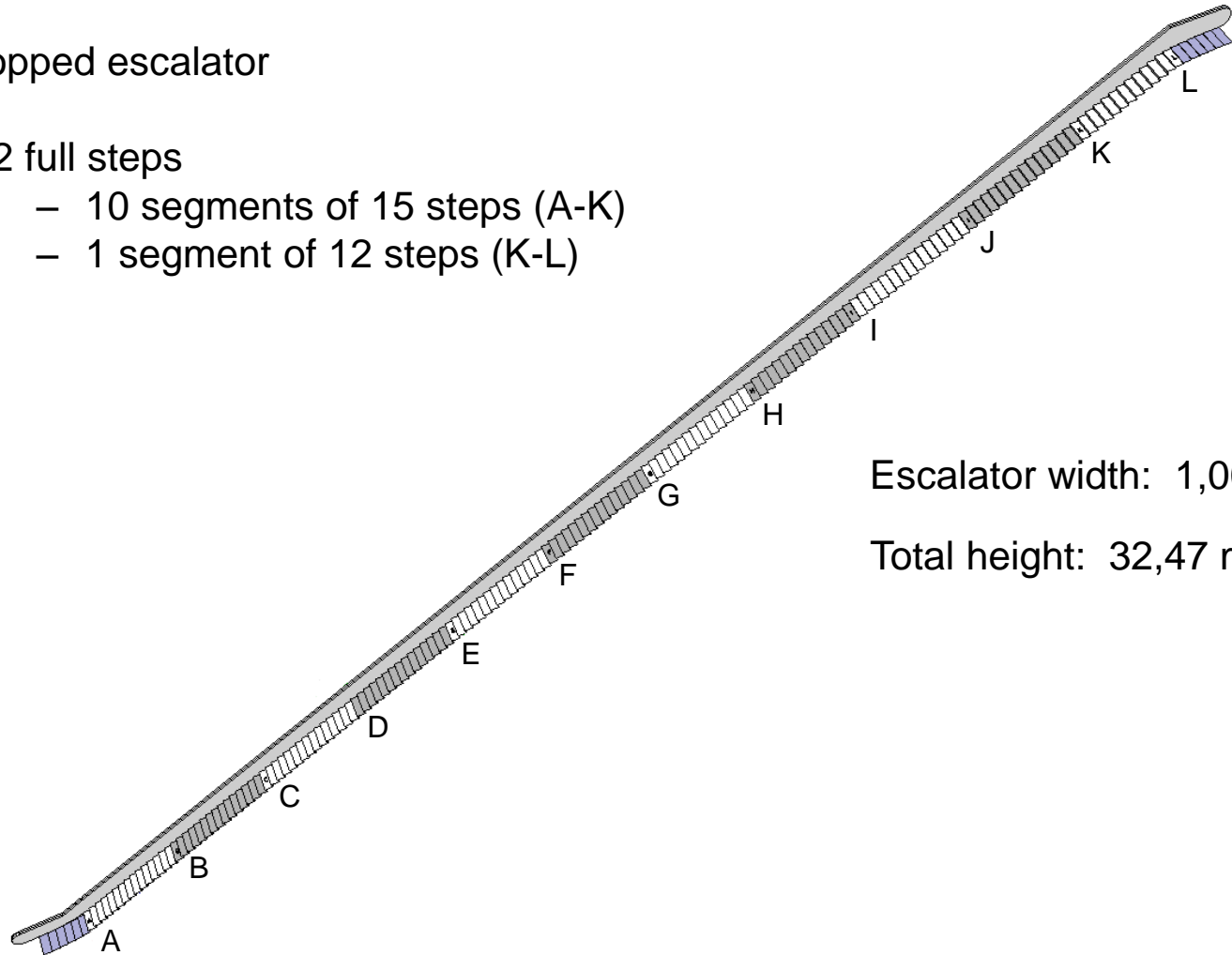
# Description

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## Stopped escalator

162 full steps

- 10 segments of 15 steps (A-K)
- 1 segment of 12 steps (K-L)



Escalator width: 1,00 m

Total height: 32,47 m



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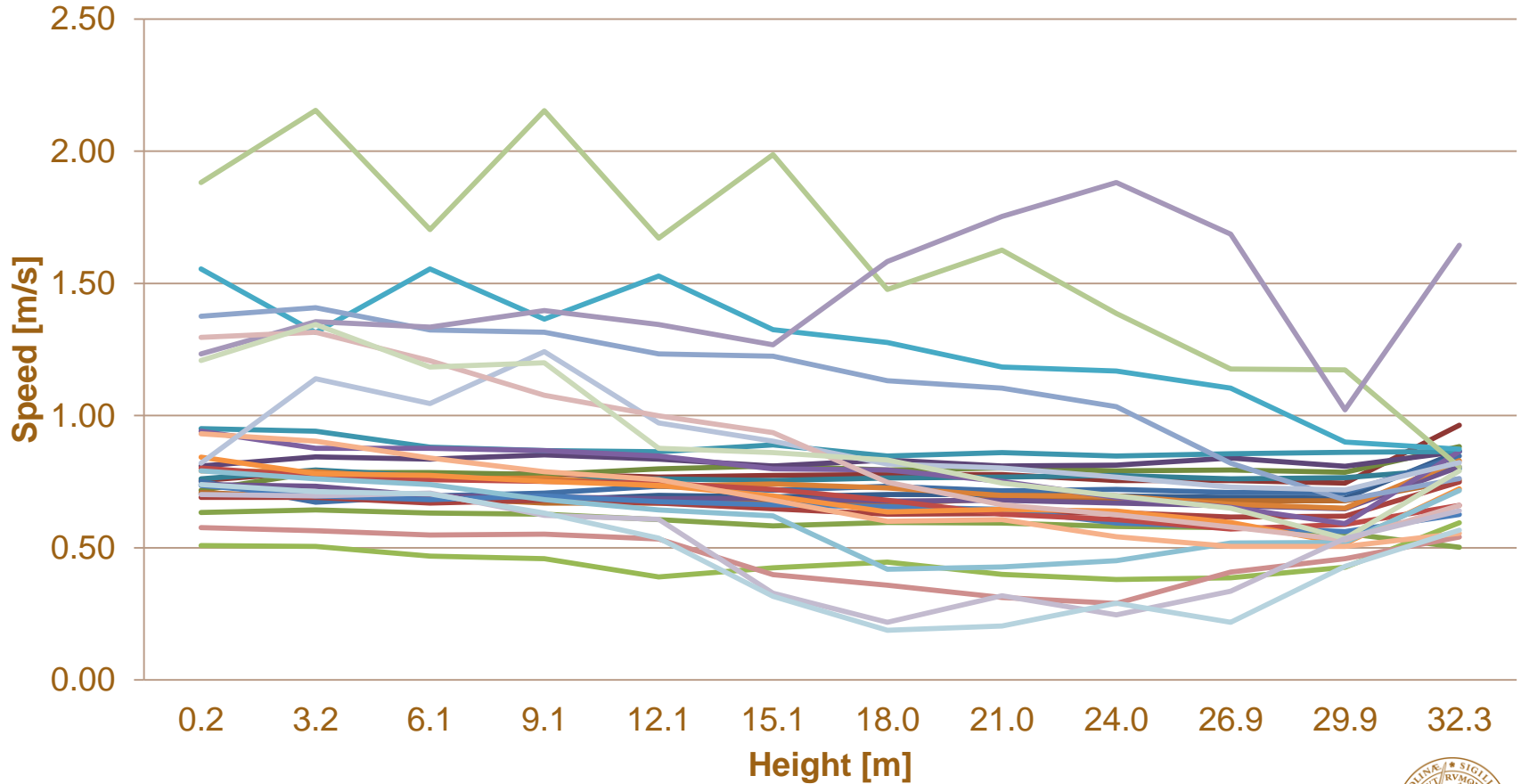
# Data analysis

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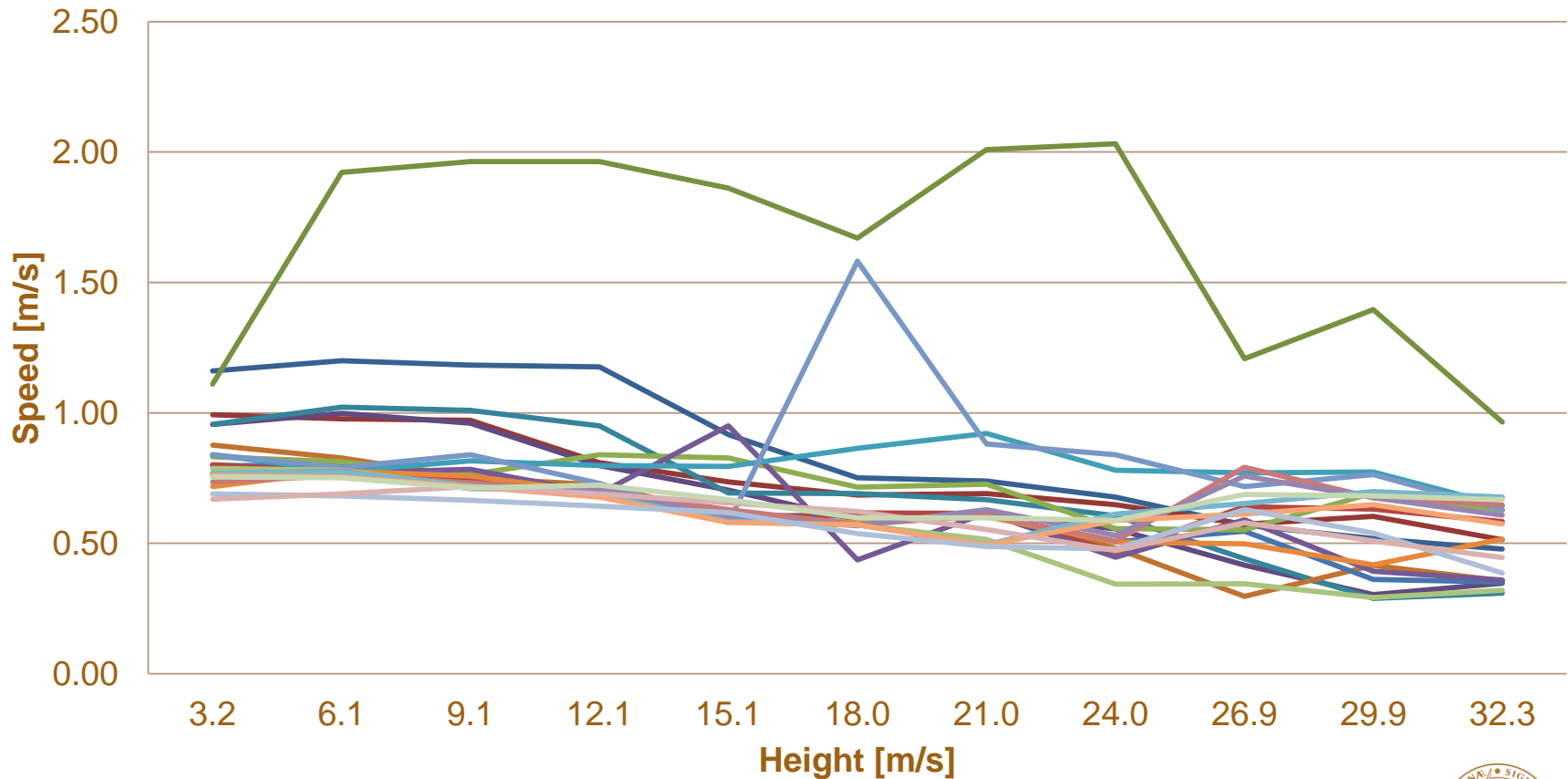
- Physiological data – Kalev and Amitava
- Videos
  - Walking speeds
  - Behavioral observations
- Questionnaire data



# Individual - Walking speed vs height

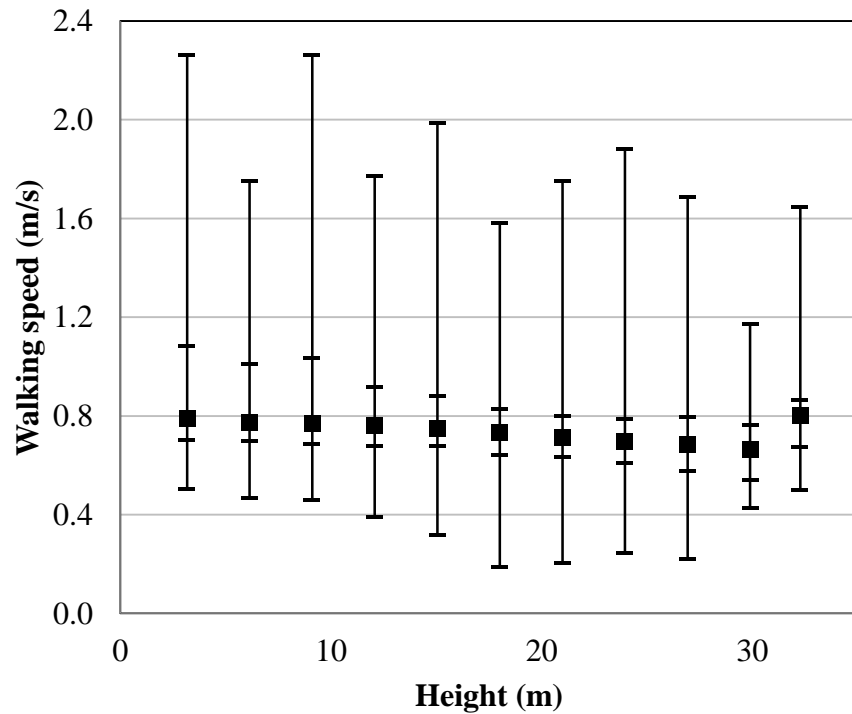


# Group – Walking speed vs height

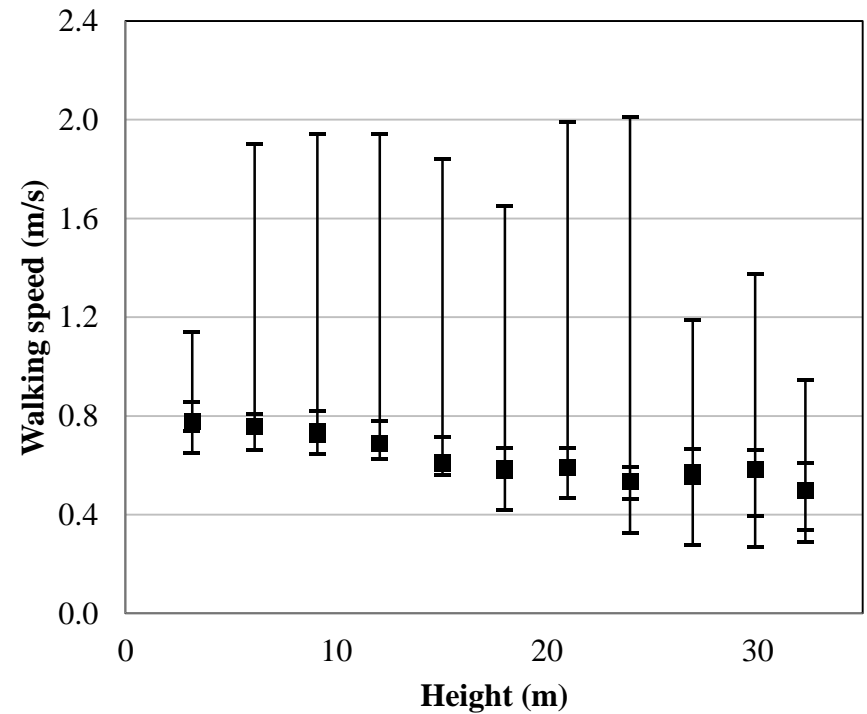


# Walking speeds

Individual experiment

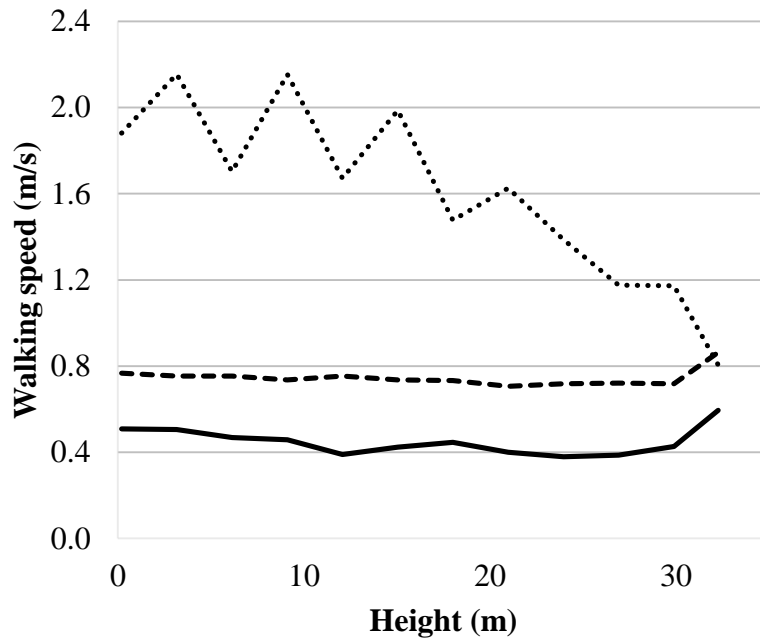


Group experiment

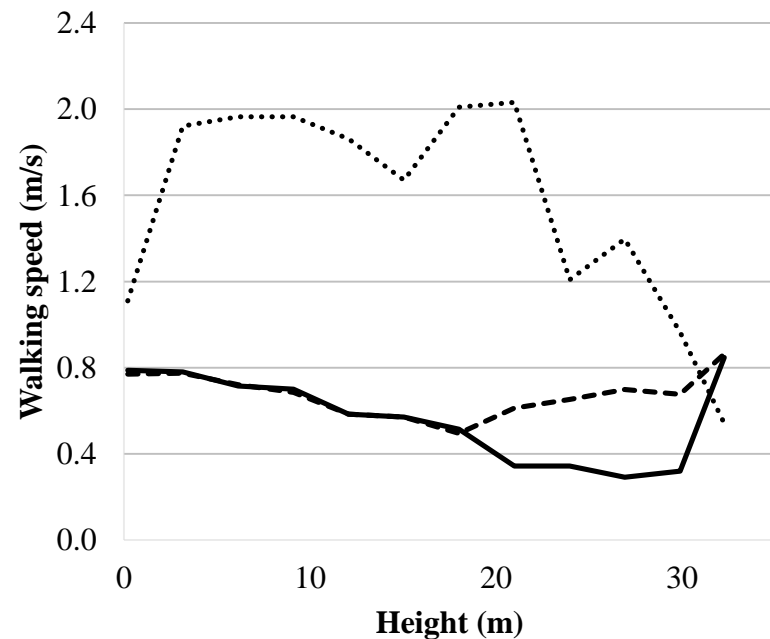


# Walking speeds

Individual experiment



Group experiment



..... Fastest person    ---- Median person    — Slowest Person

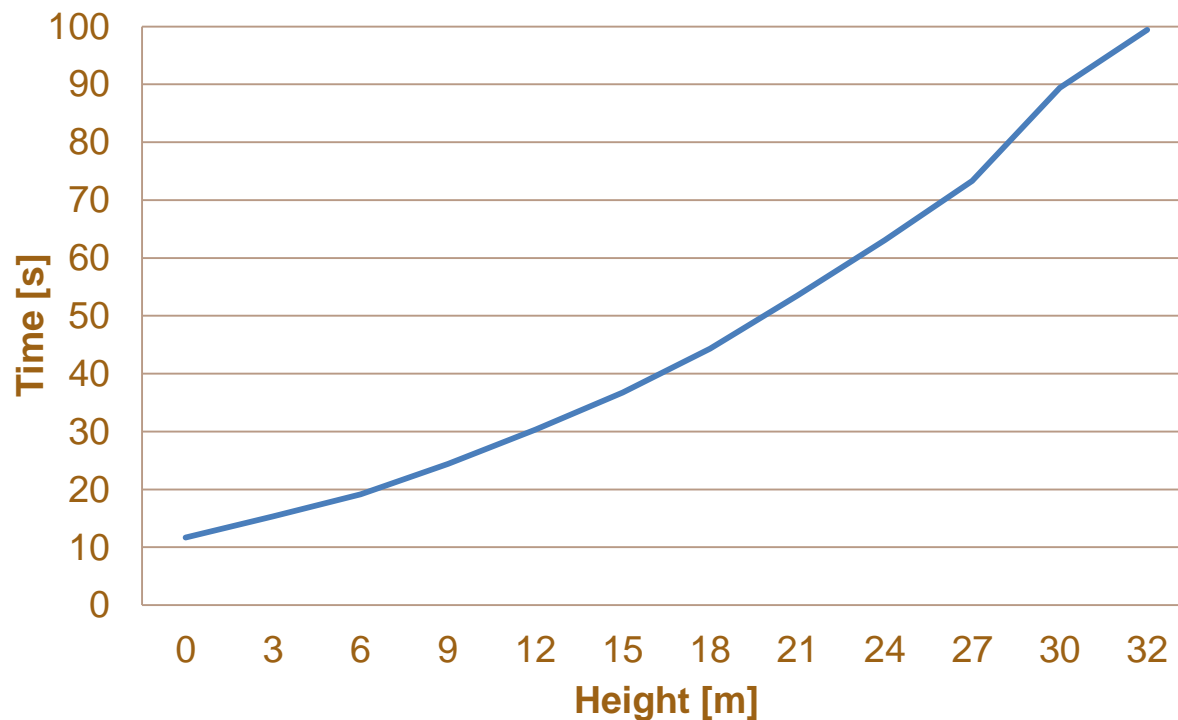


# Walking speeds

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- Density
- Overtaking

Whole group passing each mark





# Questionnaire data

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- Age
- Gender
- Height
- Weight
- Disability
- Fitness
- Tiredness
- Public transport
- Resting



# Statistical analysis

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## Dependent variables

- Average speed
- Normalized speed
- Vertical speed

## Independent variables - I

- Age
- Gender
- Disability
- Fitness
- Tiredness
- Resting
- Public transport
- **Body surface area BSA**

## Independent variables - II

- Age
- Gender
- Disability
- Fitness
- Tiredness
- Resting
- Public transport
- **Height**
- **Weight**



# Statistical analysis

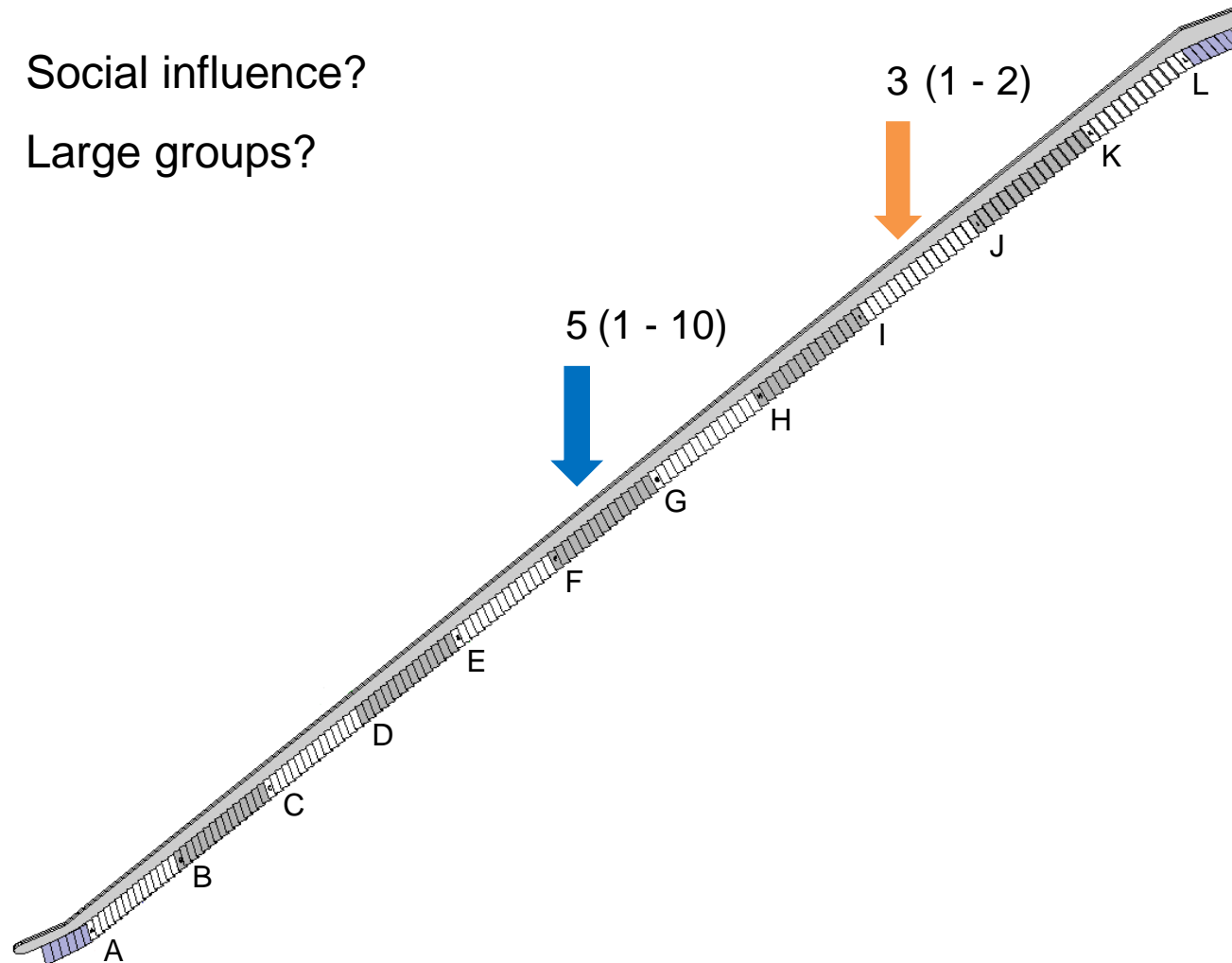
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- Regression model does not fully explain the data
  - Self-reported variables
- Most predictive variables
  - Weight
  - Disability\*
  - Tiredness\*



# Resting

- Social influence?
- Large groups?



# Borg scale

- Indicates the exertion level
- Self reported verbally – on videos

## Exertion scale

6	No exertion at all
7	Extremely light
8	
9	Very light
10	
11	Light
12	
13	Somewhat hard
14	
15	Hard (heavy)
16	
17	Very hard
18	
19	Extremely hard
20	Maximal exertion

	A	C	E	G	I	K
R	7	9	13	14	19	20
	6	9	13	13	19	20
R	6	7	13	13	17	20
	3	10	14	17	17	20
	-	12	13	16	18	20
	-	7	11	13	-	20
	-	-	11	15	17	20
	11	12	15	17	18	19
	-	11	12	15	17	19
	8	13	16	17	17	18
	-	11	14	16	17	18
	10	11	12	14	16	17
	8	10	11	13	15	17
	6	11	14	15	16	17
	6	7	11	14	15	17
	6	6	13	15	15	17
	-	13	14	15	16	17
	11	13	13	16	16	16
	7	8	11	13	14	16
	6	9	13	15	15	16
	6	7	11	15	15	16
	6	8	8	9	14	15
	6	9	9	13	13	14
	6	7	8	9	14	14
	9	11	11	14	16	13
	7	7	8	9	9	10
R	9	12	16	18	19	-



# Borg scale vs height in meters

Ideon

8	16	24	31	39	48
9	13	15	16	13	19
7	11	13	16	17	18
	13	15	13	17	18
13	15	16	16	17	17
7	13	15	16	16	17
10	14	16	16	16	17
7	12	15	15	17	17
11	12	16	16	16	17
9		14	16	17	17
7	8	13	13	16	17
10		14	15	16	17
11	14	15	16	16	16
9	10	12	14	15	16
10	11	13	15	15	16
7	13	14	16	16	16
13	15	16	15	15	16
11	13	14	16	16	16
15	12	13	14	15	16
9	13	14	16	16	16
8	11	14	15	16	16
11	12	13	14	15	16
7	13	13	15	15	16
11	13	14	15	16	16
12	13	15	16	16	16
9	15	16	16	16	16
	15	15	16	16	16
12	14	14	15	15	15
11	13	14	15	15	15
8	9	13	15	18	15
6	7	9	13	15	15
7	9	12	13	13	13
9	10	13	13	13	13
	11	14	14	13	13
13	14	15	16	16	13
8	14	16	17	17	
11	14	15	16	16	
9	14	14	17	15	
11	14	16	15	14	
12	14	17	19	19	
9	13	15	16	17	

Kista

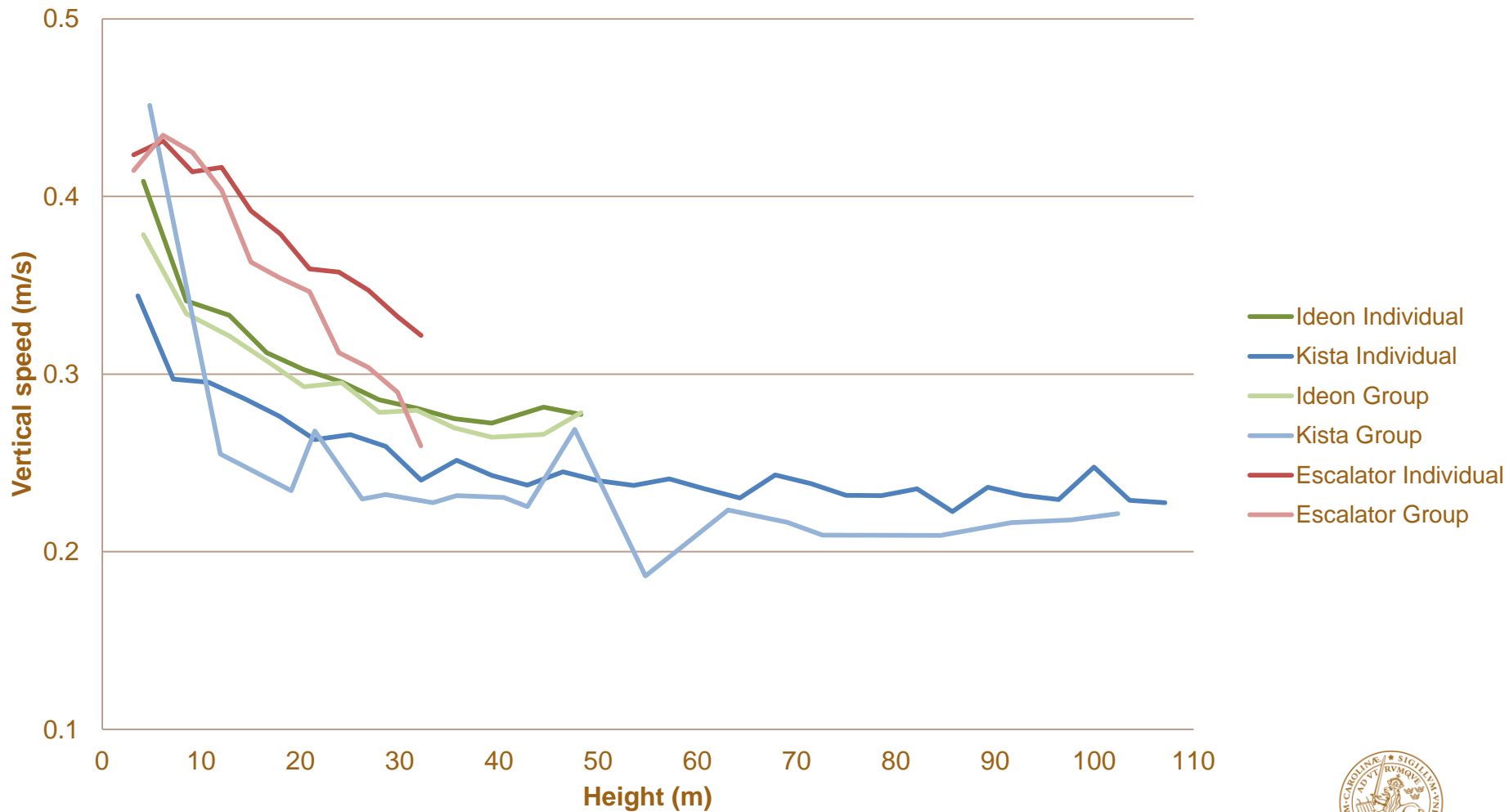
0	17	38	59	81	102
6	15	16	17	18	19
6	14	16	17	18	19
		16	17		19
17	15	16	17	18	18
10	14	16	17	18	18
	11	15	16	18	18
6	15	16		18	18
6	16	20	16	17	17
6	7	14	15	16	17
11	14			17	16
6	14	17	16	16	16
6	15		16	16	16
9	14	15	15	15	15
6	15	16	14	12	15
	9	12	14	14	14
	15	18	19	20	
6	16			18	
	16	16	17	17	
6	14	15	16	16	
	16	15	15	14	
	13		20		
	13	15			
10	17				

Escalator

0	6	12	18	24	30
7	9	13	14	19	20
6	9	13	13	19	20
6	7	13	13	17	20
6	10	14	17	17	20
	12	13	16	18	20
	7	11	13		20
		11	15	17	20
11	12	15	17	18	19
	11	12	15	17	19
8	13	16	17	17	18
	11	14	16	17	18
10	11	12	14	16	17
8	10	11	13	15	17
6	11	14	15	16	17
6	7	11	14	15	17
6	6	13	15	15	17
	13	14	15	16	17
11	13	13	16	16	16
7	8	11	13	14	16
6	9	13	15	15	16
6	7	11	15	15	16
6	8	8	9	14	15
6	9	9	13	13	14
6	7	8	9	14	14
9	11	11	14	16	13
7	7	8	9	9	10
9	12	16	18	19	



## Mean vertical speed



# Conclusions

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- **Useful dataset on walking speeds**
- Reduction of speed with the height
  - Demographic limitations should be observed
- Influence of the escalator design
  - Width affects overtaking
  - Higher risers
  - Lack of landings for micropauses on muscles
    - » Overall vertical speed reduction



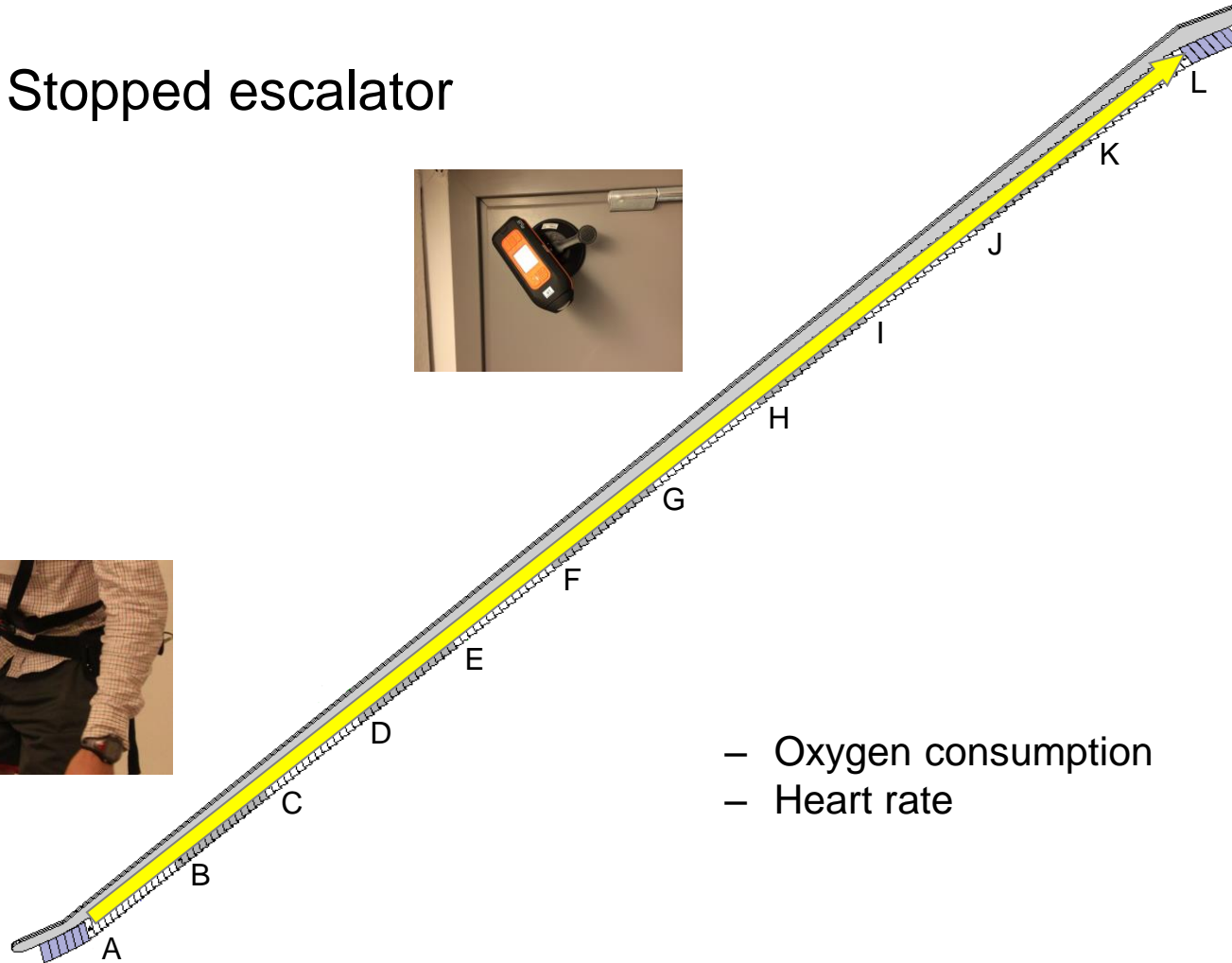


Thanks for your attention



# Procedure

- Stopped escalator



- Oxygen consumption
- Heart rate



# Statistical analysis

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- Multiple linear regression
- Dependent variables:
  - Walking speed: from each individual through the whole escalator
  - Average normalized speed: as a function of the individual's maximum speed

A	B	C	D	E	F	G	H	I	J	K
0,74	0,71	0,70	0,63	0,54	0,32	0,19	0,20	0,29	0,22	0,43
100%	96%	95%	86%	73%	43%	26%	28%	39%	30%	58%



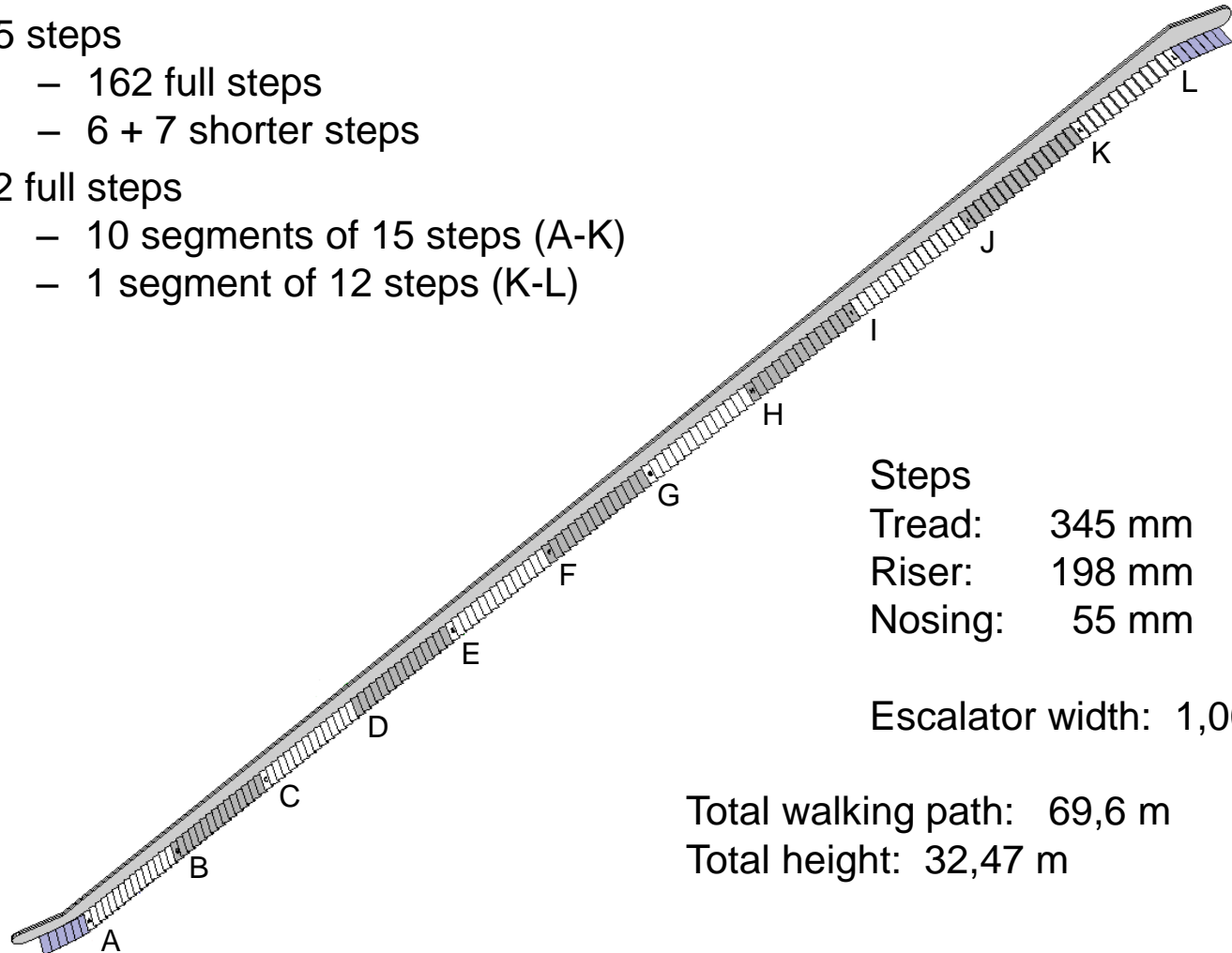
# Description

175 steps

- 162 full steps
- 6 + 7 shorter steps

162 full steps

- 10 segments of 15 steps (A-K)
- 1 segment of 12 steps (K-L)



Steps

Tread: 345 mm

Riser: 198 mm

Nosing: 55 mm

Escalator width: 1,00 m

Total walking path: 69,6 m

Total height: 32,47 m



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# Volunteers

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- Recruited through ads on social media

Escalator	Number of subjects	M vs F	Avg. age [years]
Individual	29	17+12	39
Group	21	11+10	29

- Population of particular interest
  - Elderly
  - Small children
  - People with disabilities\*
  - Pregnant women
  - Others



# Body surface area

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- A better indicator of mass than body weight
- Gives a better description of the person's complexion than just height or just weight
- Du Bois formula:

$$BSA = 0,007184W^{0,425}H^{0,725}$$

*where W is the weight in kilograms and H is the height in centimeters –  
BSA measured in m<sup>2</sup>*

- Height and weight were self reported via questionnaire

# Handrail use

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- Most people did not use it
- Some used one side (or both) the whole time
- Some used it for only few steps



# Fitness level

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- Self reported via questionnaire
- How many times do you do exercise in a week?
  - 1 = "never"
  - 5 = "5 or more times a week"

Answer	Effect
Never	None
Once a week	None
Two or more times a week	Fit





# Tiredness

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- Self reported via questionnaire
- "How (tired) do you feel today?"
  - 1 = "very tired"
  - 5 = "relaxed"



# Resting

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- Observed on videos
- Resting periods included in the average speed of the individual



# Disability

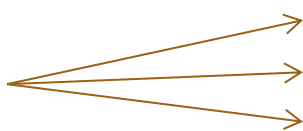
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- Self reported via questionnaire
- Broken ligament
  - Only two participants



# Use of public transportation

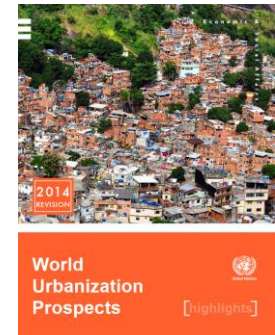
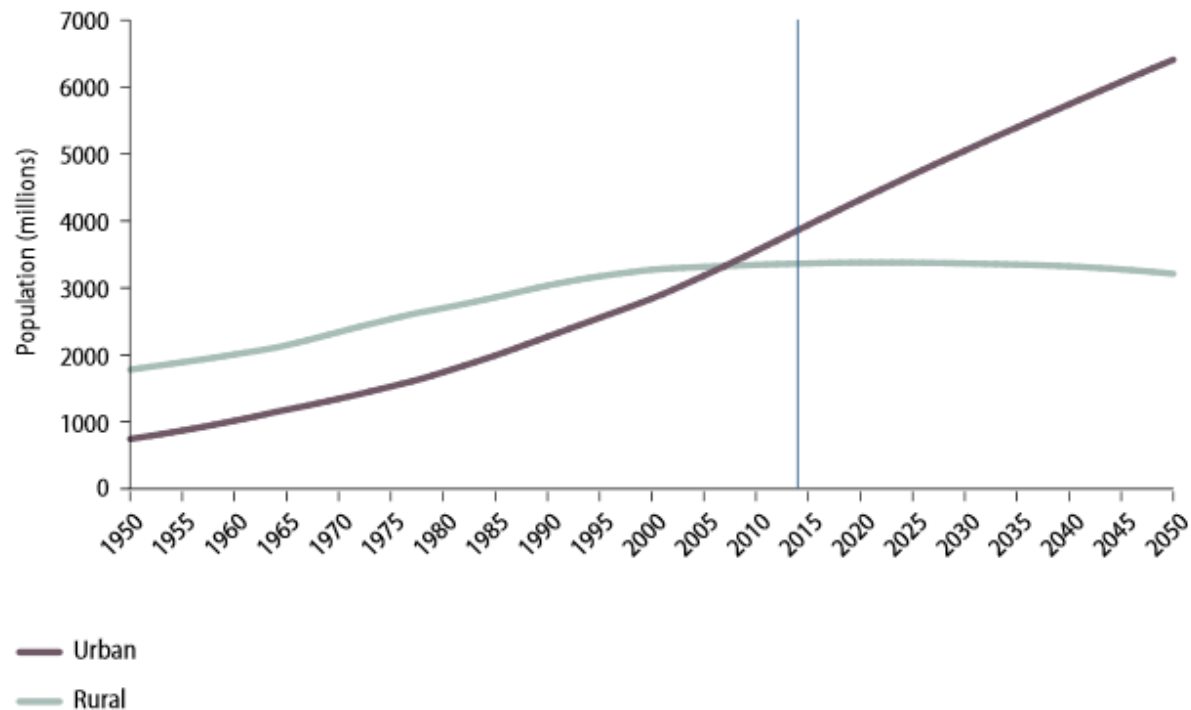
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- Self reported
  - 1 = "never" 
    - commutes by car
    - commutes by bike
    - commutes by walking
  - 4 = "daily"



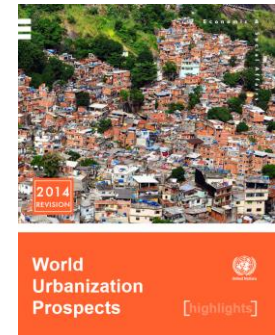
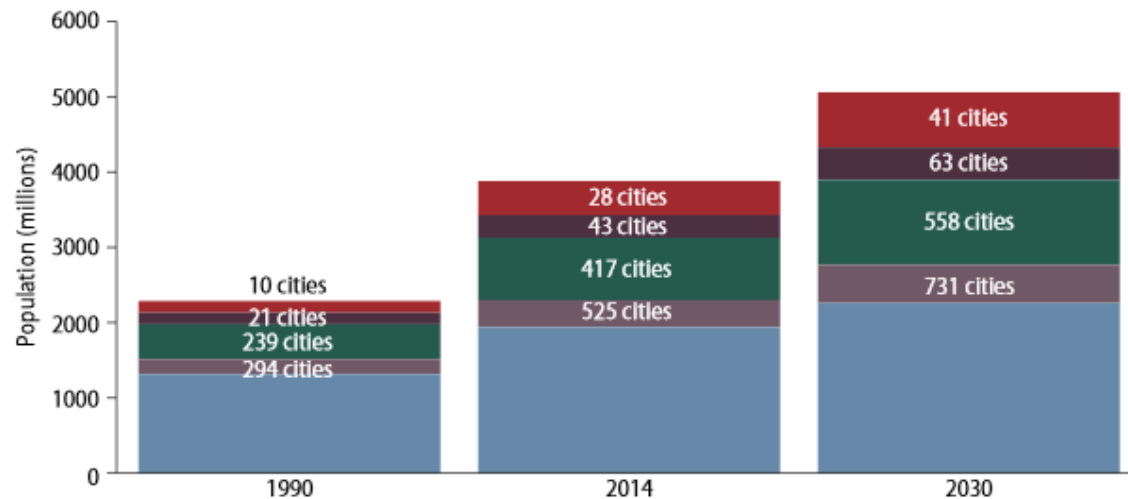
# Why ascending evacuation?

Urban and rural population of the world, 1950–2050



# Why ascending stair?

Global urban population growth is propelled by the growth of cities of all sizes



- Megacities of 10 million or more
- Large cities of 5 to 10 million
- Medium-sized cities of 1 to 5 million
- Cities of 500 000 to 1 million
- Urban areas smaller than 500 000



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# DV: total average speed/vertical speed

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Escalator			
Case	DV	Model	R square adjusted
BSA	Avg speed	Gender	0,336
		BSA	
		Disability	
H&W	Avg speed	Gender	0,370
		Weight	
		Disability	
noGender_ BSA	Avg speed	Age	0,237
		Disability	
noGender_ H&W	Avg speed	Age	0,422
		Height	
		Weight	
		Disability	
noGender_ BSA_noDisab	Avg speed		
noGender_ H&W_ noDisab	Avg speed	Age	0,300
		Height	
		Weight	

- R square adjusted values are low
- Some IV are not self reported



# DV: normalized speed

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Escalator			
Case	DV	Model	R square adjusted
BSA	N speed	Tiredness	0,574
		Resting	
H&W	N speed	Tiredness	0,574
		Resting	
noGender_ BSA	N speed	Tiredness	0,574
		Resting	
noGender_ H&W	N speed	Tiredness	0,574
		Resting	
noGender_ BSA_noDisab	N speed	Tiredness	0,567
		Resting	
noGender_ H&W_noDisab	N speed	Tiredness	0,567
		Resting	

- R square adjusted values better but still low
- IV are not very descriptive
  - Resting is the most important factor
  - Tiredness is very subjective

