
GOTOV DATA COLLECTION PROTOCOL

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Introduction

The data creation procedure was performed during the GOTO validation (GOTOv) study and it was motivated by several studies using accelerometry data, within Leiden University Medical Center (LUMC) [1, 2, 3, 4].

The goal of the GOTOv study was to create an annotated accelerometry dataset in order to interpret the existing free-living accelerometry data from the prementioned studies. Adding to that, the study aimed to the collection of further information about daily activities' intensity and energy expenditure. The study took place at LUMC, between February and May 2015. During this period, 35 (14 female, 21 male) individuals performed numerous everyday-activities while wearing different devices in several body locations.

Selection criteria

The participants were selected via a paper advertisement and they had to meet the following specific criteria:

- Be older than 60 years of age.
- Have a BMI between 23 and 35 kg/m².
- Not being restricted in their movements by health conditions.
- Bring their own bike.

The candidates filled a webform questionnaire and those reported to suffer from type 2 diabetes, cancer, heart failure or COPD2 were excluded. The selected individuals wore 4 different devices in 6 different body locations. In Table 1 the selected participants statistics are displayed.

Every individual performed a set of 16 everyday life activities, for approximately an hour and 30 minutes, following a specific protocol. The devices and body locations were selected based on the previous bio-medical studies within LUMC. If a device was severely limiting the participant in his/her movement, it was removed. The data collection protocol is reported in detail below.

	Male	Female	Total
N (%)	21 (60%)	14 (40%)	35
Age in years (SD)	64.9 (3.8)	66.7 (5.6)	65.6 (4.7)
Height in cm (SD)	178.6 (5.0)	166.9 (5.4)	173.9 (7.7)
Weight in kg (SD)	88.0 (9.8)	73.7 (5.9)	82.3 (10.0)
BMI in kg/m ² (SD)	27.6 (2.8)	26.5 (2.2)	27.15 (2.7)

Table 1: Participants details

Protocol

The 35 participants performed the set of 16 activities following a specific protocol. During that time, a researcher asked the participants to perform every activity during a time window. However, no other instructions or illustrations of the activities were given. After that, the researcher monitored the activities and recorded their start and end times. The order, duration (expected and average measured) and description of activities are presented in Table 2. A visual example of the procedure can be found in a recorded video¹. Adding to that, every participant filled a physical activity questionnaire (IPAQ) [5], just before the monitoring protocol started.

Before every individual started the sequence of activities, there was a prior sensor calibration step of *COSMED* that took approximately 10 to 15 minutes. Following that, the individuals jumped lightly for 20 seconds, while waving their arms around. This procedure creates a recognisable pattern in the data, that is used to synchronise the sensors. Subsequently, the different activities were performed in the two environments, indoors and outdoors, with the outdoor activities performed in the immediate vicinity of the research building. Between every two activities (except lying down right and left), the participants were always standing for more than 1 min, providing this way with a clear demarcation to the signal data.

Activity	Description	Duration in seconds
Jumping	Lightly jump (synchronise sensors).	20 (20.1)
Standing	Get some rest between the two activities.	60 (62)
Step	Stepping a step 20 times at participant's pace.	60 (40.6)
Lying down left	Turn 90 degrees to the left.	180 (179.1)
Lying down right	Turn 90 degrees to the right.	180 (177.7)
Sitting sofa	Sit and watch TV (feet touch the ground).	180 (177)
Sitting couch	Sit and read a newspaper (feet on the Couch).	180 (180)
Sitting chair	Sit on an office chair word on a Computer.	180 (173.1)
Walking stairs up	Ascend two flights of stairs.	20 (17.3)
Washing dishes	Stand and wash dishes.	180 (180)
Stacking shelves	Stack shelves with books.	180 (180.6)
Vacuum cleaning	Perform some cleaning with a vacuum cleaner.	180 (181.6)
Walking slow	Walk at a slow pace.	300 (298.4)
Walking normal	Walk at a medium pace.	300 (299)
Walking fast	Walk at a fast pace.	300 (285.2)
Cycling	Cycle at a normal pace.	900 (724.4)

Table 2: The 16 Activities protocol.

¹<https://youtu.be/jvx5FGhqPxx>

Devices and body locations

The devices and their body locations were selected to serve Leiden biomedical studies mentioned before. The set of devices included both accelerometry sensors and sensors measuring participants' physical information, e.g. breathing rate (BR) and volume (VO₂, VCO₂) or heart rate (HR). The goal of using those sets of sensors is to observe diverse parameters for body motion or energy expenditure. In Figure 1, the details of the devices and their respective body locations are presented. In more detail, we used the GENEActiv accelerometer on the ankle, wrist and chest, the Equivital measuring both accelerometry and other physical information on the chest, and the COSMED K4b² measuring breath volume (indirect calorimetry) using a face mask and wearable unit on the torso. If a device was severely limiting a participant's movement, it was removed (7 out of 35 participants did not use at least one device). Table 3 displays the details of every participant, the devices used and the total activity time recorded².

ID	Gender	Age (years)	Weight (Kg)	Length (cm)	BMI kg/m ²	GENEActiv			Equivital Chest	COSMED		Activity Time (min)
						Ankle	Chest	Wrist		Inside	Outside	
GOTOV02	female	62.8	83.2	167	29.8	0	0	1	1	0	0	54.9
GOTOV03	male	66.2	74.5	177	23.8	1	0	1	1	0	0	55.2
GOTOV04	female	62.5	75.6	163	28.5	1	0	1	1	0	0	53.6
GOTOV05	female	61.6	68.6	162	26.1	1	1	1	1	1	1	39.0
GOTOV06	male	59.7	84	177	26.8	1	1	1	1	1	1	43.1
GOTOV07	male	68.8	91	180	28.1	1	1	1	1	1	1	53.3
GOTOV08	male	65.6	95	172	32.1	1	1	1	1	1	1	55.3
GOTOV09	male	64.6	80.2	172	27.1	1	1	1	0	1	1	55.5
GOTOV10	male	66	84.6	180	26.1	1	1	1	1	1	1	52.4
GOTOV11	male	65.6	96	187	27.5	1	1	1	1	1	1	55.3
GOTOV12	male	60.8	99.3	190	27.5	1	0	1	1	1	1	52.3
GOTOV13	female	64.3	66	161	25.5	1	1	1	1	1	0	27.4
GOTOV14	male	63.9	117	182	35.3	1	1	1	1	1	0	27.4
GOTOV15	male	69.5	82.9	182	25	1	1	1	1	1	1	42.8
GOTOV16	female	72.5	74.6	168	26.4	1	1	1	1	1	1	55.5
GOTOV17	female	62.6	64.1	163	24.1	1	1	1	1	1	1	54.2
GOTOV18	male	59.5	77.6	180	24	1	1	1	1	1	0	53.9
GOTOV19	female	68.4	70.7	172	23.9	1	0	1	1	0	0	56.3
GOTOV20	male	62.7	93	178	29.4	1	1	1	1	1	1	53.1
GOTOV21	male	62.8	90.6	182	27.4	1	1	1	1	1	1	54.8
GOTOV22	male	60.8	83.3	184	24.6	1	1	1	1	1	0	27.3
GOTOV23	female	66.2	78.2	170	27.1	1	0	1	1	1	0	25.4
GOTOV24	female	70.9	69.8	160	27.3	1	1	1	1	1	0	27.3
GOTOV25	male	69.4	85	168	30.1	1	1	1	1	1	0	27.2
GOTOV26	female	70.9	81.9	161	31.6	1	1	1	1	1	0	27.5
GOTOV27	male	64	98.9	179	30.9	1	1	1	1	1	0	53.6
GOTOV28	female	61.5	82.7	178	26.1	1	1	1	1	1	1	50.3
GOTOV29	male	74.7	93.1	178	29.4	1	1	1	1	1	1	52.8
GOTOV30	male	67.3	88.1	174	29.1	1	1	1	1	1	0	53.2
GOTOV31	female	60.4	70.1	170	24.3	1	1	1	1	1	1	53.8
GOTOV32	female	68.1	74.1	175	24.2	1	1	1	1	1	0	27.3
GOTOV33	male	68.1	75.9	175	24.8	1	1	1	1	1	1	54.0
GOTOV34	male	62.5	77.3	176	25	1	1	1	1	1	0	27.1
GOTOV35	male	60.3	81.3	178	25.7	1	1	1	1	1	1	49.9
GOTOV36	female	81.3	72	167	25.8	1	1	1	1	1	0	27.3
Total						34	29	35	34	31	18	1579.1

Table 3: Data Overview

²In the repository we include a csv file (GOTOV_DataSummary.csv) with all participant's details and their recorded time in seconds per activity

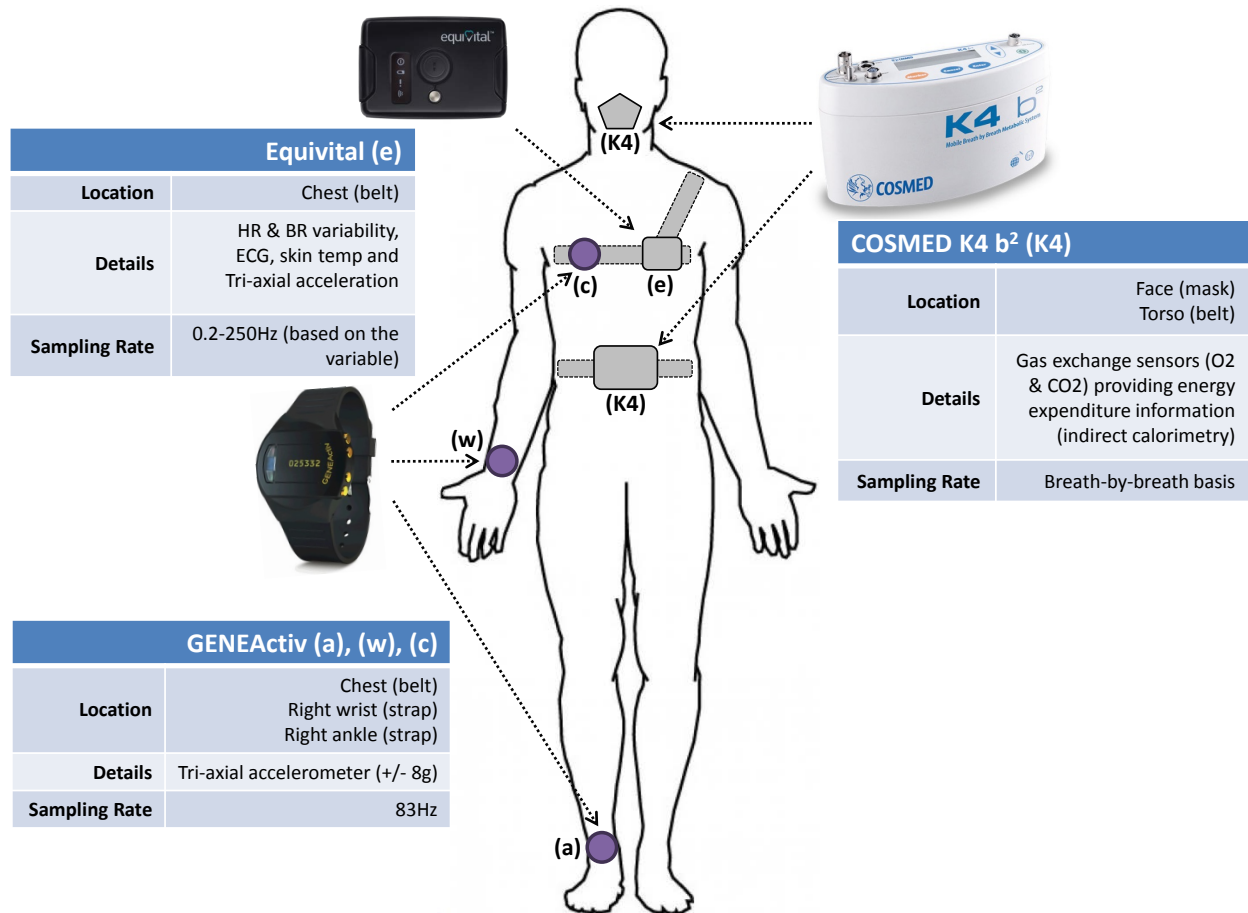


Figure 1: GOTOV study devices and their body location.

Sensor description

1. The GENEActiv measures tri-axial acceleration with a high sampling frequency (88Hz). It will be attached to the right wrist and right ankle using a strap.
2. The Equivital belt measures, among others, heart rate and heart rate variability, respiration parameters and acceleration (tri-axial). It will be attached to the participant's chest using a belt.
3. The COSMED K4b2 provides information on energy expenditure (indirect calorimetry) by means of a facial mask and sensor unit. The sensor unit quantifies the pulmonary gas exchange (VO₂, VCO₂) on a breath-by-breath basis. The K4b2 will be attached to the subject's torso using a proprietary belt (equipment weight < 1 kg). The gas exchange analysis will take place by means of a proper mask to be placed in front of subject's nose and mouth. The COSMED K4b2 consists of four main parts:
 - (a) Facemask: Plastic hypoallergenic mask, used to collect the expired gases.
 - (b) Interface between the mask and the sensor unit. This consists of a turbine connected to a flow transducer, which is connected to the sensor unit via gas tight tubing.
 - (c) Sensor unit: consists of an O₂ as well as a CO₂ sensor, a processor and a memory. This unit is equipped with an air pump in order to sample the inspired and expired air.
 - (d) Battery: The 6V battery powers the sensor unit for around 2 hours.

The dataset made public is already a product of multiple pre-processing steps. Those steps assure that all the devices are synchronised and the activity labels are imputed according to protocol. Since every device uses different time formats, all timestamps were converted to a UNIX format. UNIX timestamps, also known as POSIX time or epoch time, allow a synchronisation precision up to the millisecond. The resulting datasets are made publicly available for each participant.

Publications

The dataset was used in the development of activity recognition and energy expenditure models that will be use in the future in studies within LUMC [1, 2, 3, 4]. There are 2 publication linked to this dataset and at least one of them should be cited when it is used:

1. *Activity Recognition using Wearable Sensors for Tracking the Elderly* [6] (<https://doi.org/10.1007/s11257-020-09268-2>)
2. *RNNs on Monitoring Physical Activity Energy Expenditure in Older People* [7] (<https://arxiv.org/abs/2006.01169>)

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