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Data Article

Loading characteristics data applied on osseointegrated implant by transfemoral bone-anchored prostheses fitted with basic components during daily activities



Laurent Frossard ^{a, b, c, d}

^a Queensland University of Technology, Brisbane, QLD, Australia

^b Griffith University, Gold Coast, QLD, Australia

^c University of the Sunshine Coast, Maroochydore, QLD, Australia

^d YourResearchProject Pty Ltd, Brisbane, QLD, Australia

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ABSTRACT

The data in this paper are related to the research articles entitled “Kinetics of transfemoral amputees with osseointegrated fixation performing common activities of daily living” (Lee et al., *Clinical Biomechanics*, 2007.22(6). p. 665–673) and “Magnitude and variability of loading on the osseointegrated implant of transfemoral amputees during walking” (Lee et al., *Med Eng Phys*, 2008.30(7).p. 825–833). This article contains the overall and individual loading characteristics applied on screw-type osseointegrated implant generated by transfemoral bone-anchored prostheses fitted with basic components during daily activities at self-selected comfortable pace. Overall and individual data was presented for the (A) spatio-temporal characteristics, (B) loading patterns, (C) loading boundaries and (D) the loading local extremum during level walking, ascending and descending ramp and stairs. Inter-participant variability of these new datasets with basic components is critical to improve the efficacy and safety of prosthetic components as well as the design of future automated algorithms and clinical trials. Online repository contains the files: <https://data.mendeley.com/datasets/hh8rjjh73w/1>.

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E-mail address: laurentfrossard@outlook.com.

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Specifications Table

Subject area	Biomechanics
More specific subject area	Gait analysis of individuals using lower limb prosthesis
Type of data	Table, Graph
How data was acquired	Ten participants ambulated with an instrumented bone-anchored prosthesis including a transducer and their own basic prosthetic knee and foot. Loading profile was recorded by a purposely build apparatus including a multi-axis JR3 transducer attached to osseointegrated fixation and connected to a laptop nearby.
Data format	Raw and Analysed
Experimental factors	All loading data were time-normalized from 0 to 100% during the support phase
Experimental features	Participants fitted with instrumented transfemoral bone-anchored prostheses were asked to perform up to five trials of level walking in straight-line, ascending and descending ramp and stairs at self-selected comfortable pace.
Data source location	Brisbane, Australia, Queensland University of Technology
Data accessibility	Data is with this article. Transparency data associated with this article can be found in the online version at https://data.mendeley.com/datasets/hh8rjih73w/1
Related research article	Lee, W., Frossard, L., Hagberg, K., Haggstrom, E., and Bränemark, R., Kinetics analysis of transfemoral amputees fitted with osseointegrated fixation performing common activities of daily living. <i>Clinical Biomechanics</i> , 2007.22(6), p. 665–673. [1]

Value of the data

- The baseline spatio-temporal characteristics as well as loading patterns, loading boundaries and loading local extremum applied on transfemoral osseointegrated implants by bone-anchored prostheses fitted with basic components during daily activities can be used in future meta-analyses or comparative studies.
- The confidence interval, mean and outliers provide new insights into inter-participants variability of loading characteristics.
- These information will be critical to scientists designing finite element models of prosthetic components and osseointegrated implants parts, algorithms capable to recognised the loading patterns applied on a residuum during daily activities, as well as clinical trials testing effects of particular interventions (e.g., effect of choice and alignment of prosthetic components). [2–6]

1. Data

The confounders of the loading characteristics data including selection criteria as well as the demographics, amputation, residuum and prosthesis, non-experimental setup and number of gait cycles analysed information are presented in Tables 1–6, respectively.

The mean and standard deviation as well as lower and upper limits of 95% confidence interval of the spatio-temporal gait characteristics, loading boundaries and loading extremum during walking, ascending and descending ramp and stairs are presented in Tables 7–11 respectively.

The box plots of the spatio-temporal gait characteristics during walking, ascending and descending ramp and stairs are presented in Figs. 1, 6, 10, 14 and 18, respectively.

The box plots of loading boundaries during walking, ascending and descending ramp and stairs are presented in Figs. 2, 7, 11, 15 and 19, respectively.

The mean and standard deviation of the pattern as well as dispersion and mean for up to three local extremum of forces and moments during walking, ascending and descending ramp and stairs are presented in Figs. 3, 8, 12, 16 and 20, respectively.

The box plots of onset of up to three local extremum of forces and moments during walking, ascending and descending ramp and stairs are presented in Figs. 4, 9, 13, 17 and 21, respectively.

The box plots of magnitude of up to three local extremum of forces and moments during walking, ascending and descending ramp and stairs are presented in Figs. 5, 10, 14, 18 and 22, respectively (see Figs. 23–25).

1.1. Confounders

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1.2. Level walking

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1.3. Ascending ramp

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1.4. Descending ramp

.

1.5. Ascending stairs

.

1.6. Descending stairs

.

2. Experimental design, materials, and methods

2.1. Participants

Ten participants with unilateral transfemoral amputation fitted with screw-type fixation (OPRA, Integrum, AB) enabling direct skeletal attachment of bone-anchored prostheses participated in these studies (Table 1, Table 2, Table 3). [1,7] This cohort represented approximately 15% of the population of fitted with transfemoral bone-anchored prostheses worldwide at the time of the recording. [1,7]

2.2. Prostheses

Participants were fitted with instrumented bone-anchored prosthesis made of a transducer and their own usual components including hydraulic knees (i.e., single-axis GaitMaster (N = 1), polycentric Total Knee 1900 (N = 6)) or microprocessor-controlled knees (i.e., single-axis Adaptive (N = 1), C-Leg (N = 2)), foot prosthetic ankle-units (Multi-axial TruStep (N = 3), Total Concept (N = 1), energy-storing-and-returning: Carbon copy (N = 2), C-Walk (N = 2), Flex Foot (N = 1), unknown (N = 1)) and footwear (Table 4).

These components are referred to as “basic” as their mechanical design are no longer as advanced as commonly prescribed components according to current best-practice (e.g., microprocessor-controlled knees, energy-storing-and-returning feet). Indeed, only two participants used a C-Leg knee recommended for transfemoral bone-anchored prostheses fitted to screw-type fixation. [6,8]

The loads were directly measured with a purposely build apparatus including a multi-axis JR3 transducer set at 200 Hz with an accuracy better than 1 N and 1 Nm, that was fitted between the participant's abutment and Rotosafe, when possible, or attached to the knee unit. [9–17]

Table 1

Selection criteria including inclusion and exclusion criteria applied for the recruitment and selection of participants using unilateral transfemoral bone-anchored prosthesis fitted with basic components.

Inclusion criteria	
1.	To be fitted with OPRA osseointegrated fixation more than 6 months prior testing
2.	To be fully rehabilitated
3.	To have at least 6 cm clearance between abutment and prosthetic knee to fit the transducer
4.	To be able to be fitted with one of the nominated basic components
5.	To be willing to participate to this project of research
6.	To be willing to comply with protocol
7.	To be able to walk 200 m independently with prosthesis
8.	To be between 18 and 80 years of age
9.	To be free of infection on the day of the recording session
Exclusion criteria	
1.	To have bilateral amputation
2.	To have self-reported pain level greater than 4 out of 10 at study outset
3.	To have experienced a fall within the last 8 weeks before assessment
4.	To have mental illness or intellectual impairment
5.	To not be able to give informed consent
6.	To have injuries involving contralateral (intact) limb
7.	To present signs of infection 2 weeks prior testing session
8.	To have major uncorrected visual deficit
9.	To have history of epilepsy or recurrent dizziness

Table 2

Overall and individual demographics information for cohorts of ten participants fitted with basic components. M: Male, F: Female, BMI: Body mass Index.

Participant	Demographics				
	Gender (M/F)	Age (Yrs)	Height (m)	Mass (kg)	BMI (kg/m ²)
1	F	57	1.63	61.10	21.679
2	M	50	1.81	74.24	21.547
3	M	59	1.85	87.12	24.316
4	M	62	1.80	105.00	31.003
5	F	49	1.58	53.30	20.029
6	M	73	1.77	96.55	29.589
7	M	26	1.78	90.00	27.048
8	M	46	1.89	99.50	26.735
9	M	48	1.82	99.80	28.967
10	M	45	1.72	80.40	25.994
Mean		52	1.77	84.70	25.691
SD		13	0.10	17.33	3.718

2.3. Recording

Participants performed up to five trials of five standardized daily activities including straight-line level walking, ascending and descending ramp and stairs (Table 5, Table 6). [7,13] Participants were instructed to complete each activity at a self-selected comfortable pace as well as to use handrails and take sufficient rest between trials to avoid fatigue if needed.

Some datasets relying on no more than three trials per activity were presented in Lee et al. (2007) and Lee et al. (2008). [1,7] Here, we purposely extracted and presented data for all five trials available to provide more thorough insights.

2.4. Loading characteristics

The raw forces and moments recorded directly by tri-axial transducer connected to a laptop nearby were imported and processed into a specifically designed Matlab program.

Table 3

Overall and individual amputations and residuum information for cohorts of ten participants fitted with basic components. TR: Trauma, TU: Tumor, IN: Infection, OT: Other, L: Left, R: Right, AMP: amputation, BAP: Bone-anchored prosthesis, %SND: Percentage of sound limb, -: missing data due to inaccessible medical record.

Participant	Amputation		Time since AMP (Yrs)	Time since BAP (Yrs)	Residuum	
	Cause	Side (L/R)			Length (cm)	Length (%SND)
1	TR	R	—	—	17.50	45.81
2	TR	L	15.4	6.71	22.30	54.13
3	TR	R	41.8	6.89	16.00	39.02
4	TR	L	16.0	3.42	35.00	71.43
5	TU	R	48.9	1.20	18.00	48.65
6	TR	R	14.3	—	17.40	41.23
7	TR	R	7.1	—	17.20	41.75
8	TR	L	21.3	5.20	—	—
9	TU	R	6.3	14.28	24.80	59.05
10	OT	R	11.8	4.62	28.00	59.57
Mean			20.3	6.05	21.80	51.18
SD			15.0	4.12	6.41	10.74

Table 4

Individual prosthesis information for cohorts of ten participants fitted with basic components.

Participant	Prosthesis		
	Knee	Ankle	Footwear
1	Total Knee	Total Concept	Sandals
2	Total Knee	TruStep	Sandals
3	Total Knee	TruStep	Leather shoes
4	Adaptive	Unknown	Running shoes
5	Total Knee	C-Walk	Running shoes
6	C-Leg	Carbon copy	Sandals
7	C-Leg	Carbon copy	Leather shoes
8	Total Knee	C-Walk	Sandals
9	GaitMaster	Flex Foot	Leather shoes
10	Total Knee	TruStep	Running shoes

Table 5

Description of non-experimental setup used for ecological direct measurements of loading applied on osseointegrated fixation by transfemoral bone-anchored prosthesis fitted with basic components during activities of daily living.

Straight level walking	
Location	Indoor
Length (m)	30
Ascending and descending ramp	
Location	Outdoor
Length (m)	12
Incline (deg)	6.5
Height of handrail (cm)	70
Ascending and descending stairs	
Location	Indoor
Number of steps	11
Height of step (cm)	30
Depth of step (cm)	34
Width of step (cm)	180
Height of handrail (cm)	80

Table 6

Breakdown of cumulated number of gait cycles analysed for the cohorts of ten participants fitted basic components performed over up to five trials during five activities of daily living.

Activity	Number of steps analysed
Level walking	555
Ascending ramp	469
Descending ramp	566
Ascending stairs	284
Descending stairs	253
Total	2,127

Table 7

Mean and standard deviation (SD) as well as lower and upper limits of 95% confidence interval (CI) of the spatio-temporal gait characteristics, loading boundaries and loading extremum (PT1, PT2, PT3) when fitted with basic components during walking (GC: Gait cycle, F: Force, M: Moment, AP: Antero-posterior, ML: Medio-lateral, LG: Long, BW: Bodyweight, SUP: Support).

	Mean	SD	95%CI-Lower	95%CI-Upper
Spatio-temporal gait characteristics				
Cadence (Strides/min)	47	4	44	49
Gait cycle (s)	1.29	0.11	1.28	1.30
Swing (s)	0.74	0.07	0.73	0.74
Support (%GC)	57	3	57	57
Swing (s)	0.55	0.07	0.55	0.56
Support (%GC)	43	3	43	43
Loading boundaries				
Minimum				
FAP (%BW)	-7.26	3.43	-7.54	-6.97
FML (%BW)	-0.51	1.02	-0.60	-0.43
FLG (%BW)	-4.72	3.22	-4.99	-4.45
MAP (%BWm)	-2.791	0.946	-2.869	-2.712
MML (%BWm)	-2.266	1.000	-2.349	-2.182
MLG (%BWm)	-0.367	0.221	-0.385	-0.349
Maximum				
FAP (%BW)	13.00	4.52	12.62	13.38
FML (%BW)	12.92	5.04	12.50	13.34
FLG (%BW)	84.73	6.93	84.16	85.31
MAP (%BWm)	0.424	0.881	0.351	0.498
MML (%BWm)	1.623	1.195	1.524	1.723
MLG (%BWm)	0.458	0.304	0.432	0.483
Loading extremum				
Onset				
FAP-PT1 (%SUP)	16.43	4.56	16.05	16.81
FAP-PT2 (%SUP)	81.41	5.43	80.96	81.86
FML-PT1 (%SUP)	63.80	17.88	62.32	65.29
FLG-PT1 (%SUP)	53.75	17.67	52.28	55.22
MAP-PT1 (%SUP)	50.82	27.66	48.52	53.12
MML-PT1 (%SUP)	17.56	11.46	16.60	18.51
MML-PT2 (%SUP)	67.46	8.46	66.76	68.16
MML-PT3 (%SUP)	94.01	3.88	93.68	94.33
MLG-PT1 (%SUP)	17.59	12.07	16.58	18.59
MLG-PT2 (%SUP)	73.47	11.17	72.54	74.40
Magnitude				
FAP-PT1 (%BW)	-7.26	3.43	-7.54	-6.97
FAP-PT2 (%BW)	13.00	4.52	12.62	13.38
FML-PT1 (%BW)	12.92	5.04	12.50	13.34
FLG-PT1 (%BW)	84.73	6.93	84.16	85.31
MRT-PT1 (%BWm)	3.516	0.850	3.445	3.587
MAP-PT1 (%BWm)	-2.787	0.946	-2.866	-2.709
MML-PT1 (%BWm)	-1.313	0.780	-1.378	-1.248
MML-PT2 (%BWm)	1.485	1.348	1.373	1.598
MML-PT3 (%BWm)	-2.197	1.047	-2.284	-2.110
MLG-PT1 (%BWm)	-0.364	0.223	-0.383	-0.345
MLG-PT2 (%BWm)	0.445	0.320	0.418	0.472

Table 8

Mean and standard deviation (SD) as well as lower and upper limits of 95% confidence interval (CI) of the spatio-temporal gait characteristics, loading boundaries and loading extremum (PT1, PT2, PT3) when fitted with basic components during ascending ramp (GC: Gait cycle, F: Force, M: Moment, AP: Antero-posterior, ML: Medio-lateral, LG: Long, BW: Bodyweight, SUP: Support).

	Mean	SD	95%CI-Lower	95%CI-Upper
Spatio-temporal gait characteristics				
Cadence (Strides/min)	46	4	43	48
Gait cycle (s)	1.29	0.11	1.28	1.30
Swing (s)	0.78	0.05	0.78	0.79
Support (%GC)	61	4	61	61
Swing (s)	0.51	0.08	0.50	0.52
Support (%GC)	39	4	39	39
Loading boundaries				
Minimum				
FAP (%BW)	-5.88	3.95	-6.24	-5.52
FML (%BW)	-0.27	0.71	-0.33	-0.20
FLG (%BW)	-1.88	1.55	-2.02	-1.74
MAP (%BWm)	-2.528	0.993	-2.618	-2.439
MML (%BWm)	-2.453	0.750	-2.521	-2.385
MLG (%BWm)	-0.358	0.217	-0.378	-0.339
Maximum				
FAP (%BW)	14.63	4.07	14.26	15.00
FML (%BW)	12.07	4.22	11.69	12.45
FLG (%BW)	91.08	5.18	90.61	91.54
MAP (%BWm)	0.228	0.690	0.165	0.290
MML (%BWm)	2.199	1.205	2.089	2.308
MLG (%BWm)	0.671	0.311	0.643	0.699
Loading extremum				
Onset				
FAP-PT1 (%SUP)	14.53	5.48	14.03	15.02
FAP-PT2 (%SUP)	81.02	5.01	80.56	81.47
FML-PT1 (%SUP)	62.23	17.48	60.64	63.81
FLG-PT1 (%SUP)	59.73	14.07	58.45	61.00
MAP-PT1 (%SUP)	35.96	24.91	33.71	38.22
MML-PT1 (%SUP)	10.59	6.24	10.03	11.16
MML-PT2 (%SUP)	55.68	12.39	54.56	56.80
MML-PT3 (%SUP)	94.09	3.40	93.78	94.40
MLG-PT1 (%SUP)	12.63	8.42	11.87	13.40
MLG-PT2 (%SUP)	55.32	22.02	53.33	57.31
Magnitude				
FAP-PT1 (%BW)	-5.88	3.95	-6.24	-5.52
FAP-PT2 (%BW)	14.63	4.07	14.26	15.00
FML-PT1 (%BW)	12.07	4.22	11.69	12.45
FLG-PT1 (%BW)	91.01	5.14	90.54	91.47
MRT-PT1 (%BWm)	3.559	0.919	3.476	3.642
MAP-PT1 (%BWm)	-2.502	0.992	-2.591	-2.412
MML-PT1 (%BWm)	-0.728	0.439	-0.768	-0.688
MML-PT2 (%BWm)	2.176	1.221	2.066	2.287
MML-PT3 (%BWm)	-2.452	0.751	-2.520	-2.384
MLG-PT1 (%BWm)	-0.333	0.230	-0.354	-0.312
MLG-PT2 (%BWm)	0.665	0.316	0.637	0.694

The load data for a given activity was extracted following a step-by-step basic processing including: calibration (e.g., Offset of raw data according to the magnitude of the load recorded during calibration), detection of relevant segment (e.g., elimination of the first and the last strides recorded for each trial to analyze only steps taken at a steady pace free of gait initiation and termination), detection of gait events (e.g., manual detection of individual heel contact and toe-off events using loading profile applied on the long axis), time normalization (e.g., time-normalization from 0 to 100 throughout the gait cycle or support phases) and bodyweight normalization (e.g., express forces and moments data as percentage of bodyweight).

Table 9

Mean and standard deviation (SD) as well as lower and upper limits of 95% confidence interval (CI) of the spatio-temporal gait characteristics, loading boundaries and loading extremum (PT1, PT2, PT3) when fitted with basic components during descending ramp (GC: Gait cycle, F: Force, M: Moment, AP: Antero-posterior, ML: Medio-lateral, LG: Long, BW: Bodyweight, SUP: Support).

	Mean	SD	95%CI-Lower	95%CI-Upper
Spatio-temporal gait characteristics				
Cadence (Strides/min)	48	6	45	52
Gait cycle (s)	1.23	0.14	1.22	1.25
Swing (s)	0.72	0.08	0.71	0.73
Support (%GC)	58	2	58	59
Swing (s)	0.51	0.07	0.51	0.52
Support (%GC)	42	2	41	42
Loading boundaries				
Minimum				
FAP (%BW)	-11.81	4.68	-12.19	-11.42
FML (%BW)	-0.14	0.63	-0.20	-0.09
FLG (%BW)	-0.90	1.64	-1.03	-0.76
MAP (%BWm)	-2.958	1.161	-3.054	-2.863
MML (%BWm)	-3.706	1.663	-3.843	-3.569
MLG (%BWm)	-0.622	0.331	-0.650	-0.595
Maximum				
FAP (%BW)	8.72	4.14	8.37	9.06
FML (%BW)	10.39	3.66	10.09	10.70
FLG (%BW)	87.69	6.95	87.12	88.27
MAP (%BWm)	0.284	0.486	0.244	0.324
MML (%BWm)	0.780	0.779	0.716	0.844
MLG (%BWm)	0.283	0.260	0.262	0.305
Loading extremum				
Onset				
FAP-PT1 (%SUP)	36.83	27.95	34.52	39.13
FAP-PT2 (%SUP)	88.12	8.55	87.42	88.82
FML-PT1 (%SUP)	59.26	17.00	57.86	60.66
FLG-PT1 (%SUP)	38.51	12.82	37.45	39.56
MAP-PT1 (%SUP)	52.07	23.83	50.11	54.04
MML-PT1 (%SUP)	14.63	24.71	12.59	16.66
MML-PT2 (%SUP)	65.01	27.07	62.78	67.24
MLG-PT1 (%SUP)	43.49	26.03	41.34	45.63
MLG-PT2 (%SUP)	47.76	38.16	44.62	50.91
Magnitude				
FAP-PT1 (%BW)	-11.81	4.68	-12.19	-11.42
FAP-PT2 (%BW)	8.15	4.80	7.76	8.55
FML-PT1 (%BW)	10.39	3.66	10.09	10.70
FLG-PT1 (%BW)	87.69	6.95	87.12	88.27
MRT-PT1 (%BWm)	4.681	1.386	4.567	4.795
MAP-PT1 (%BWm)	-2.958	1.161	-3.054	-2.863
MML-PT1 (%BWm)	0.780	0.779	0.716	0.844
MML-PT2 (%BWm)	-3.706	1.663	-3.843	-3.569
MLG-PT1 (%BWm)	-0.622	0.331	-0.650	-0.595
MLG-PT2 (%BWm)	0.283	0.260	0.262	0.305

The characterization of loading profile for each activity was achieved through more advanced processing to extract spatio-temporal gait characteristics (e.g., cadence, duration of gait cycle as well as support and swing phases), loading patterns, loading boundaries (e.g., minimum and maximum of forces and moments expressed in %BW and %BWm for all gait cycles considered regardless of the onset), up to three loading local extremum (e.g., semi-automatic detection of onsets (%SUP) and magnitudes (%BW or %BWm) of points of inflection between loading slopes occurring consistently over successive gait cycles across all participants). [1,3,7,10–13,18]

The continuous data (e.g., loading pattern) was represented by mean and one standard deviation. For all discrete datasets (e.g., spatio-temporal gait characteristics, loading boundaries, local extremum), the confidence intervals were calculated using the CONFIDENCE function in Microsoft Excel 2010 and

Table 10

Mean and standard deviation (SD) as well as lower and upper limits of 95% confidence interval (CI) of the spatio-temporal gait characteristics, loading boundaries and loading extremum (PT1, PT2, PT3) when fitted with basic components during ascending stairs (GC: Gait cycle, F: Force, M: Moment, AP: Antero-posterior, ML: Medio-lateral, LG: Long, BW: Bodyweight, SUP: Support).

	Mean	SD	95%CI-Lower	95%CI-Upper
Spatio-temporal gait characteristics				
Cadence (Strides/min)	45	5	42	48
Gait cycle (s)	1.33	0.17	1.31	1.34
Swing (s)	0.70	0.09	0.69	0.71
Support (%GC)	53	4	52	53
Swing (s)	0.63	0.12	0.61	0.64
Support (%GC)	47	4	47	48
Loading boundaries				
Minimum				
FAP (%BW)	-2.95	2.68	-3.26	-2.63
FML (%BW)	-0.46	0.61	-0.53	-0.39
FLG (%BW)	-2.26	2.23	-2.52	-2.00
MAP (%BWm)	-1.964	0.919	-2.070	-1.857
MML (%BWm)	-0.753	0.388	-0.798	-0.708
MLG (%BWm)	-0.274	0.199	-0.297	-0.250
Maximum				
FAP (%BW)	6.79	3.48	6.39	7.20
FML (%BW)	10.23	3.78	9.79	10.67
FLG (%BW)	100.43	9.28	99.35	101.51
MAP (%BWm)	0.625	0.550	0.561	0.689
MML (%BWm)	1.298	1.042	1.177	1.419
MLG (%BWm)	0.320	0.242	0.292	0.348
Loading extremum				
Onset				
FAP-PT1 (%SUP)	13.38	14.51	11.70	15.07
FAP-PT2 (%SUP)	86.71	5.99	86.01	87.40
FML-PT1 (%SUP)	58.94	23.07	56.26	61.63
FLG-PT1 (%SUP)	42.01	18.97	39.80	44.22
MAP-PT1 (%SUP)	47.01	24.82	44.13	49.90
MML-PT1 (%SUP)	60.54	28.20	57.26	63.82
MLG-PT1 (%SUP)	32.88	29.35	29.46	36.29
MLG-PT2 (%SUP)	66.89	30.53	63.34	70.44
Magnitude				
FAP-PT1 (%BW)	-2.89	2.74	-3.21	-2.57
FAP-PT2 (%BW)	6.76	3.54	6.35	7.17
FML-PT1 (%BW)	10.23	3.78	9.79	10.67
FLG-PT1 (%BW)	100.43	9.28	99.35	101.51
MRT-PT1 (%BWm)	2.513	0.996	2.397	2.628
MAP-PT1 (%BWm)	-1.943	0.964	-2.055	-1.831
MML-PT1 (%BWm)	1.227	1.111	1.098	1.356
MLG-PT1 (%BWm)	-0.257	0.203	-0.281	-0.233
MLG-PT2 (%BWm)	0.308	0.255	0.278	0.338

Table 11

Mean and standard deviation (SD) as well as lower and upper limits of 95% confidence interval (CI) of the spatio-temporal gait characteristics, loading boundaries and loading extremum (PT1, PT2, PT3) when fitted with basic components during descending stairs (GC: Gait cycle, F: Force, M: Moment, AP: Antero-posterior, ML: Medio-lateral, LG: Long, BW: Bodyweight, SUP: Support).

	Mean	SD	95%CI-Lower	95%CI-Upper
Spatio-temporal gait characteristics				
Cadence (Strides/min)	47	7	43	52
Gait cycle (s)	1.27	0.22	1.24	1.30
Swing (s)	0.61	0.10	0.60	0.62
Support (%GC)	48	5	47	49
Swing (s)	0.66	0.16	0.64	0.68
Support (%GC)	52	5	51	53
Loading boundaries				
Minimum				
FAP (%BW)	-10.50	8.59	-11.56	-9.44
FML (%BW)	-0.73	1.14	-0.87	-0.59
FLG (%BW)	-0.66	1.03	-0.79	-0.54
MAP (%BWm)	-2.179	0.920	-2.292	-2.066
MML (%BWm)	-1.924	1.899	-2.158	-1.690
MLG (%BWm)	-0.398	0.330	-0.439	-0.357
Maximum				
FAP (%BW)	2.92	3.32	2.52	3.33
FML (%BW)	7.05	2.08	6.79	7.30
FLG (%BW)	85.09	12.37	83.56	86.61
MAP (%BWm)	0.483	0.359	0.439	0.527
MML (%BWm)	1.511	1.117	1.373	1.649
MLG (%BWm)	0.383	0.240	0.353	0.412
Loading extremum				
Onset				
FAP-PT1 (%SUP)	33.78	28.24	30.30	37.26
FML-PT1 (%SUP)	55.47	18.75	53.16	57.78
FLG-PT1 (%SUP)	51.78	16.95	49.69	53.87
MAP-PT1 (%SUP)	46.87	25.12	43.78	49.97
MML-PT1 (%SUP)	58.01	35.00	53.70	62.32
MLG-PT1 (%SUP)	56.28	33.20	52.19	60.37
Magnitude				
FAP-PT1 (%BW)	-10.50	8.59	-11.56	-9.44
FML-PT1 (%BW)	6.97	2.13	6.71	7.23
FLG-PT1 (%BW)	85.09	12.37	83.56	86.61
MRT-PT1 (%BWm)	3.439	1.459	3.259	3.619
MAP-PT1 (%BWm)	-2.157	0.930	-2.271	-2.042
MML-PT1 (%BWm)	-1.832	1.978	-2.076	-1.588
MLG-PT1 (%BWm)	-0.398	0.330	-0.439	-0.357

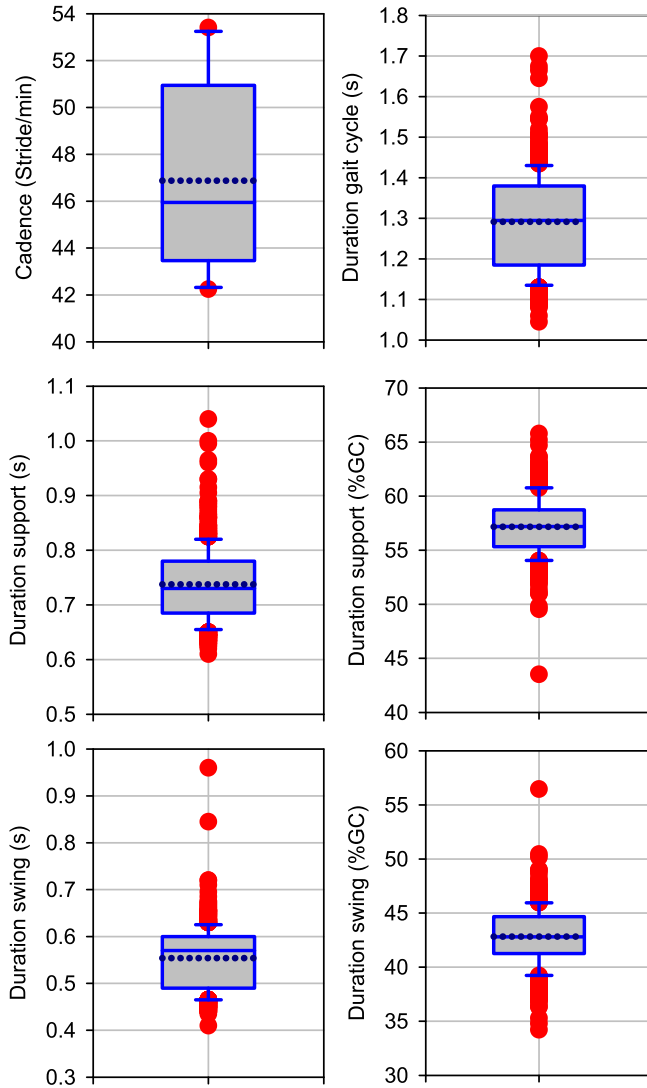


Fig. 1. Box plots showing low and high 95% confidence interval, mean and outliers of the spatio-temporal gait characteristics including cadence, duration of gait cycle (GC) as well as support and swing phases when fitted with basic components during walking.

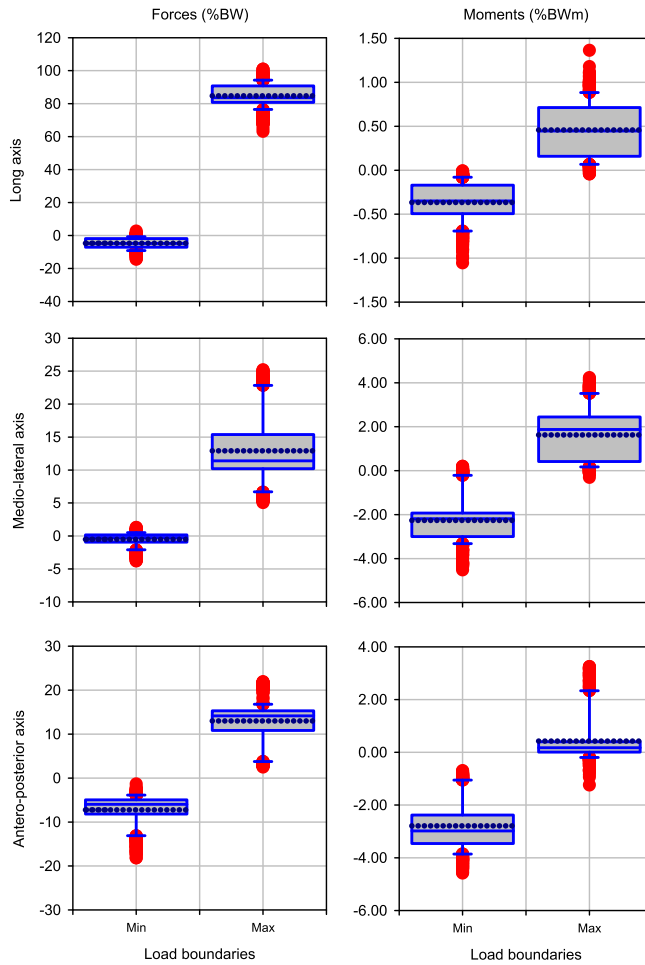


Fig. 2. Box plots showing low and high 95% confidence interval, mean and outliers of the loading boundaries including minimum (Min) and maximum (Max) of forces and moments applied when fitted with basic components during walking.

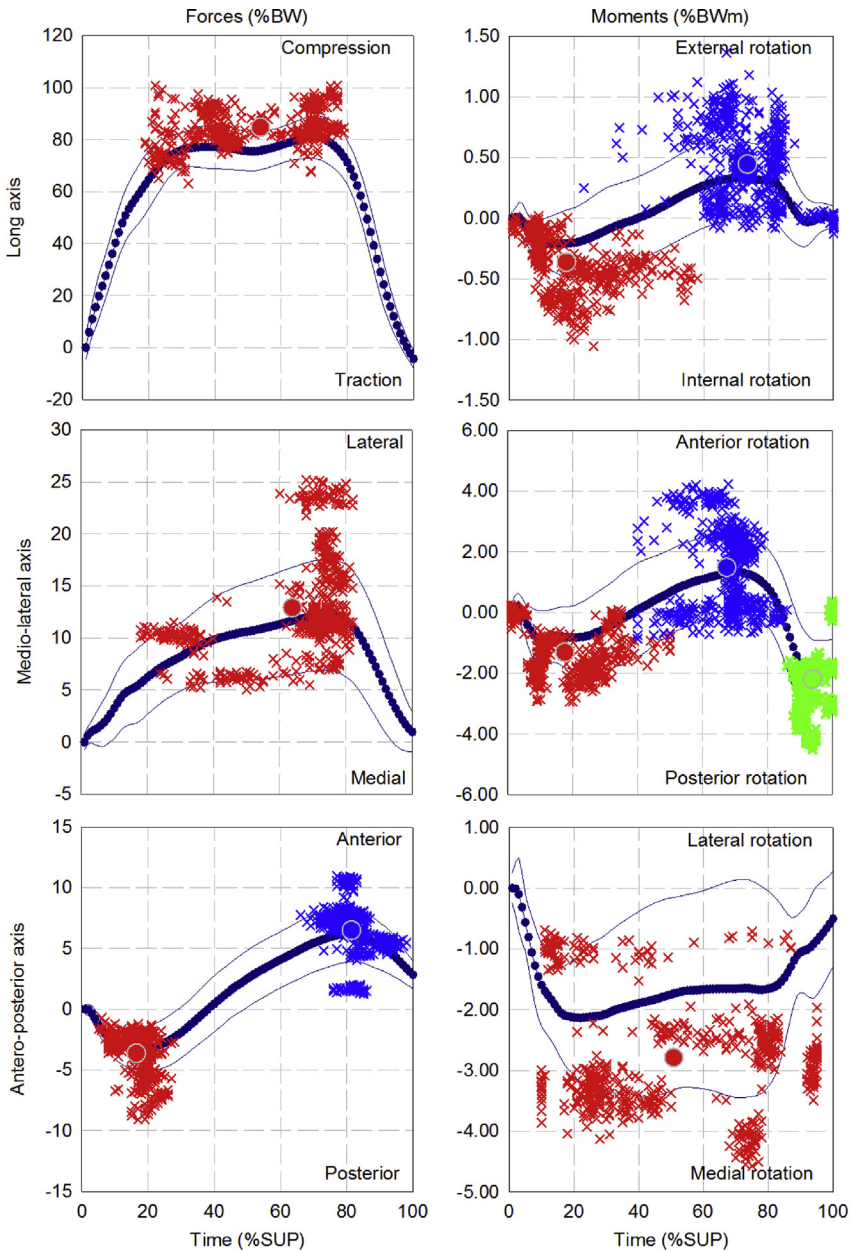


Fig. 3. Mean and standard deviation of the pattern as well as dispersion (cross) and mean (circle) for first (red), second (bleu) and third (green) local extremum of forces and moments for cohort of participants fitted with basic components during walking (N = 555 gait cycles).

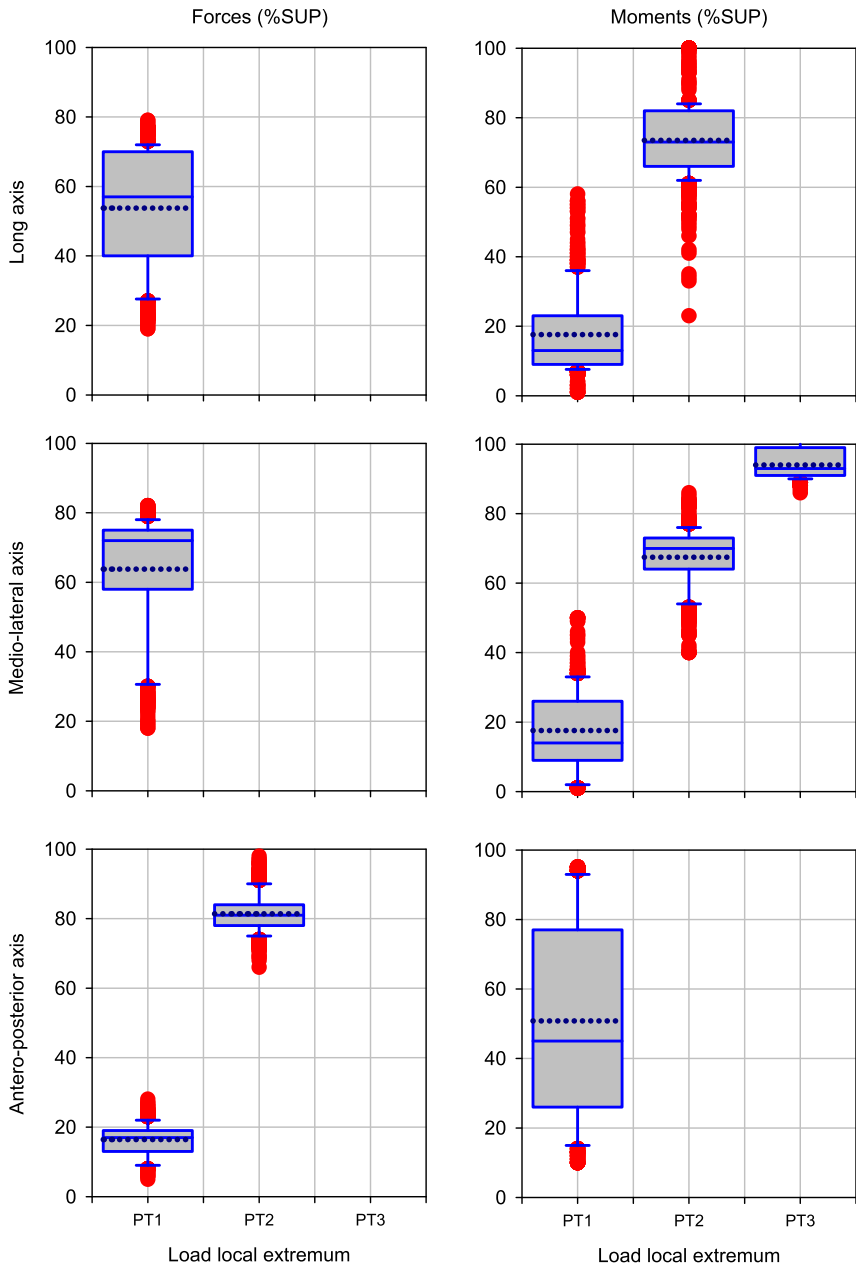


Fig. 4. Box plots showing low and high 95% confidence interval, mean and outliers of the onset expressed in percentage of support phase (%SUP) of up to three local extremum (PT1, PT2, PT3) of forces and moments applied with basic components during walking.

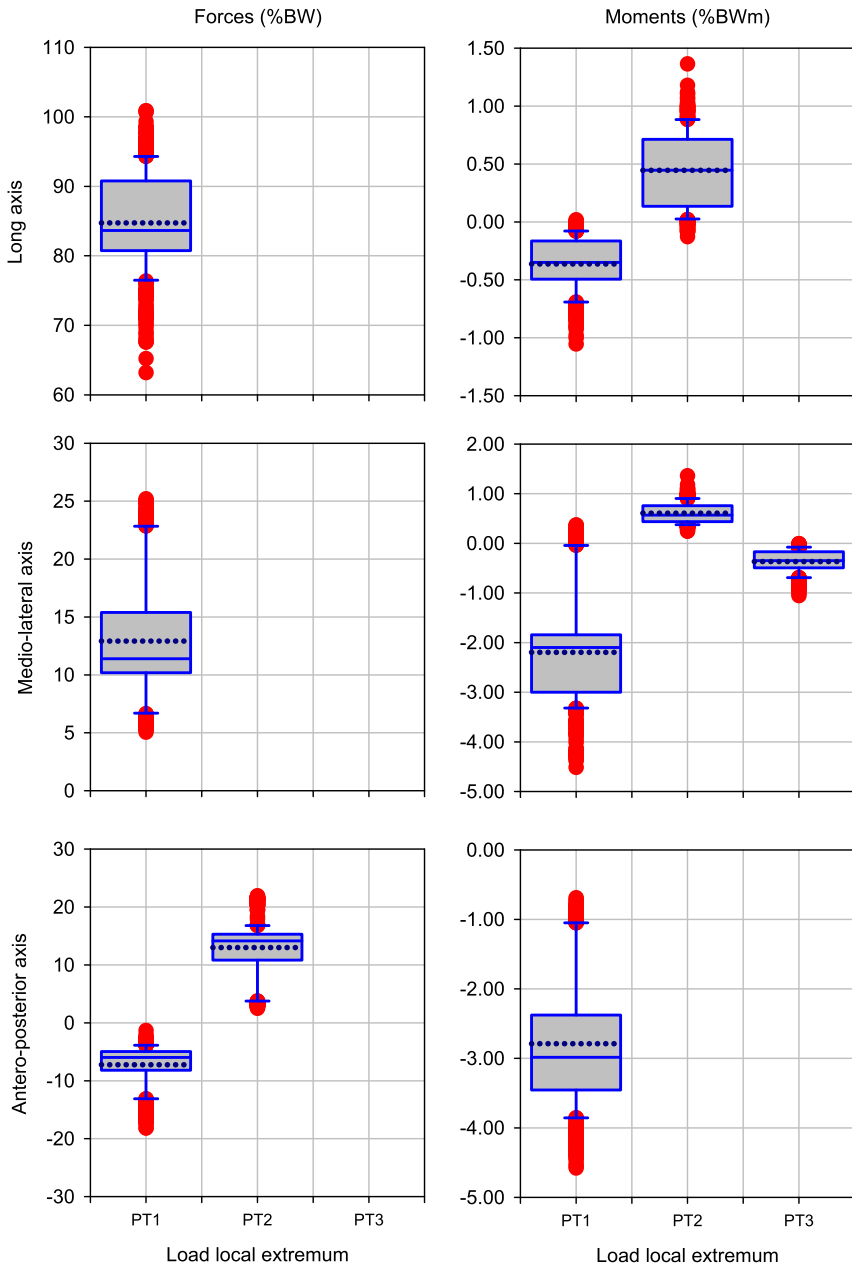


Fig. 5. Box plots showing low and high 95% confidence interval, mean and outliers of the magnitude expressed in percentage of bodyweight (%BW, %BWm) of up to three local extremum (PT1, PT2, PT3) of forces and moments applied with basic components during walking.

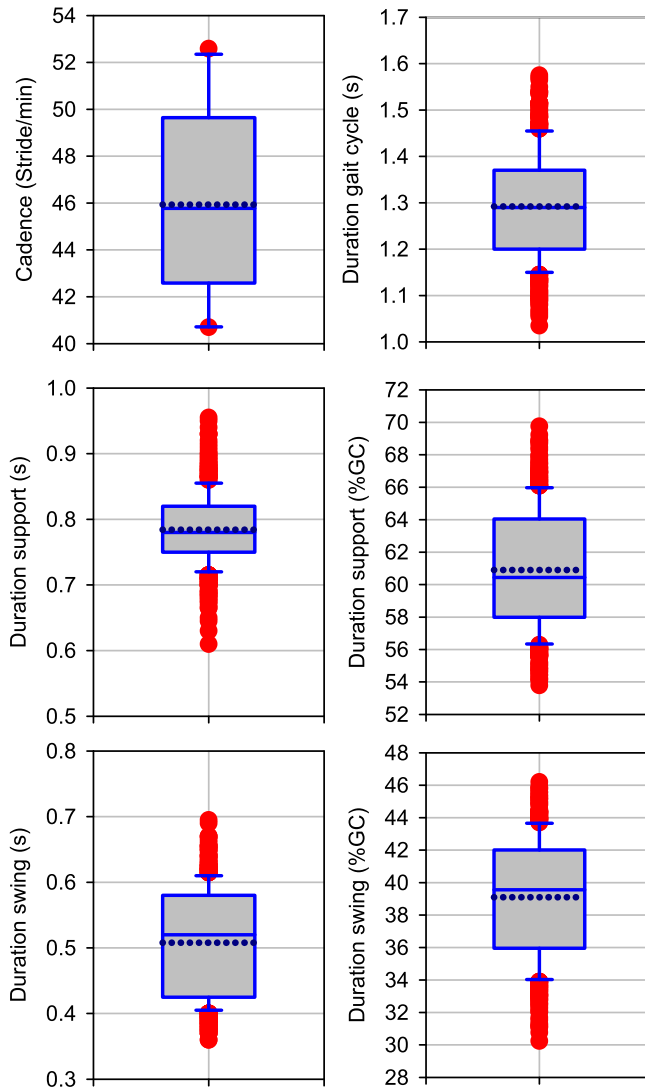


Fig. 6. Box plots showing low and high 95% confidence interval, mean and outliers of the spatio-temporal gait characteristics including cadence, duration of gait cycle (GC) as well as support and swing phases when fitted with basic components during ascending ramp.

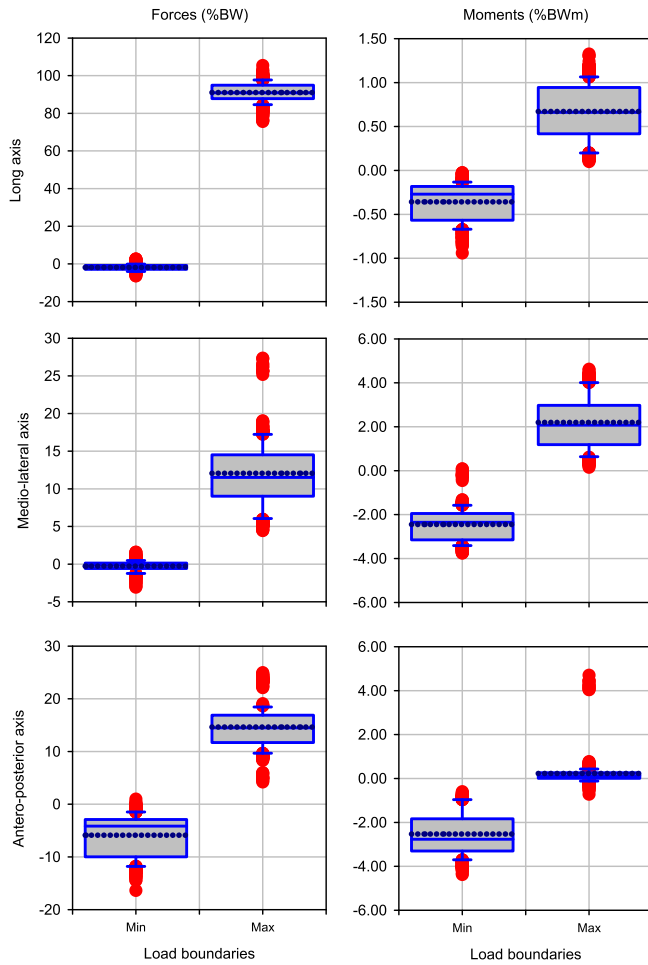


Fig. 7. Box plots showing low and high 95% confidence interval, mean and outliers of the loading boundaries including minimum (Min) and maximum (Max) of forces and moments applied when fitted with basic components during ascending ramp.

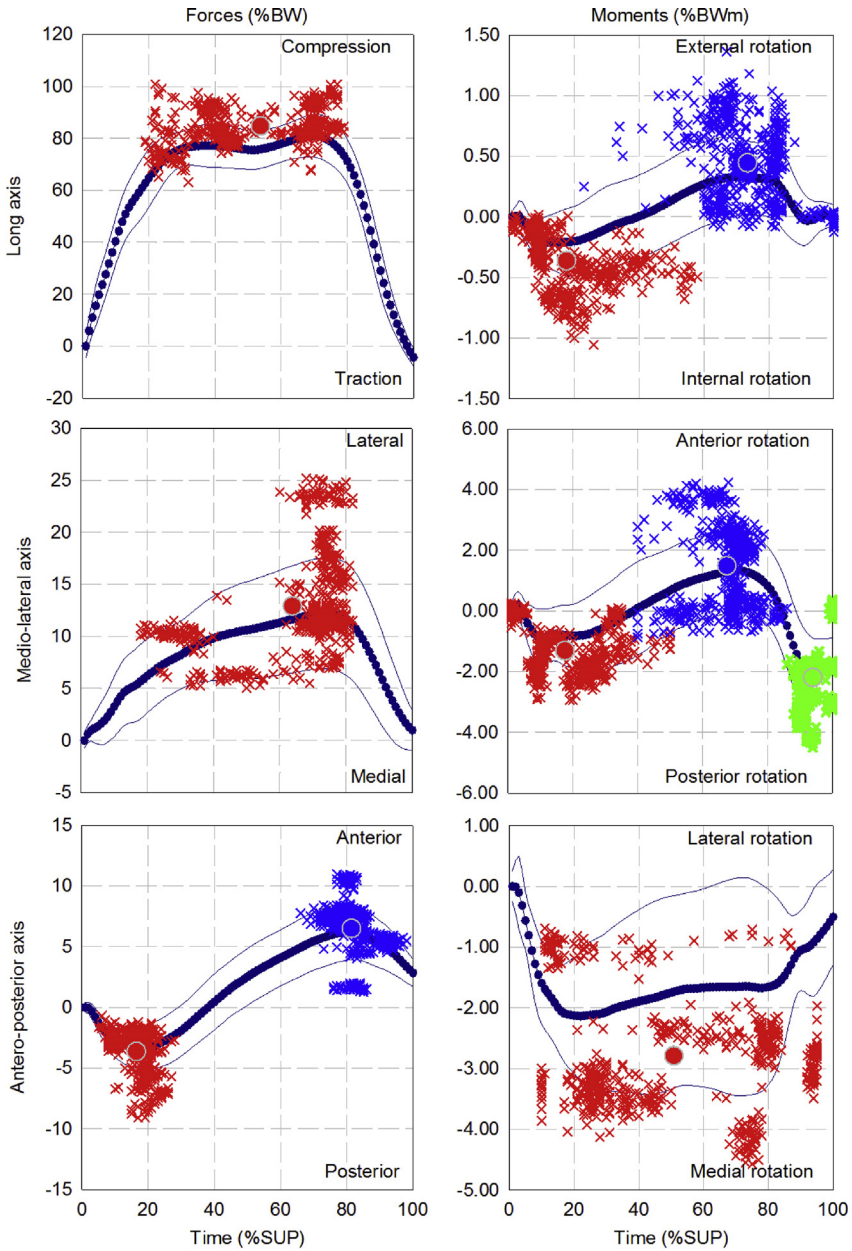


Fig. 8. Mean and standard deviation of the pattern as well as dispersion (cross) and mean (circle) for first (red), second (blue) and third (green) local extremum of forces and moments for cohort of participants fitted with basic components (469 gait cycles) during ascending ramp.

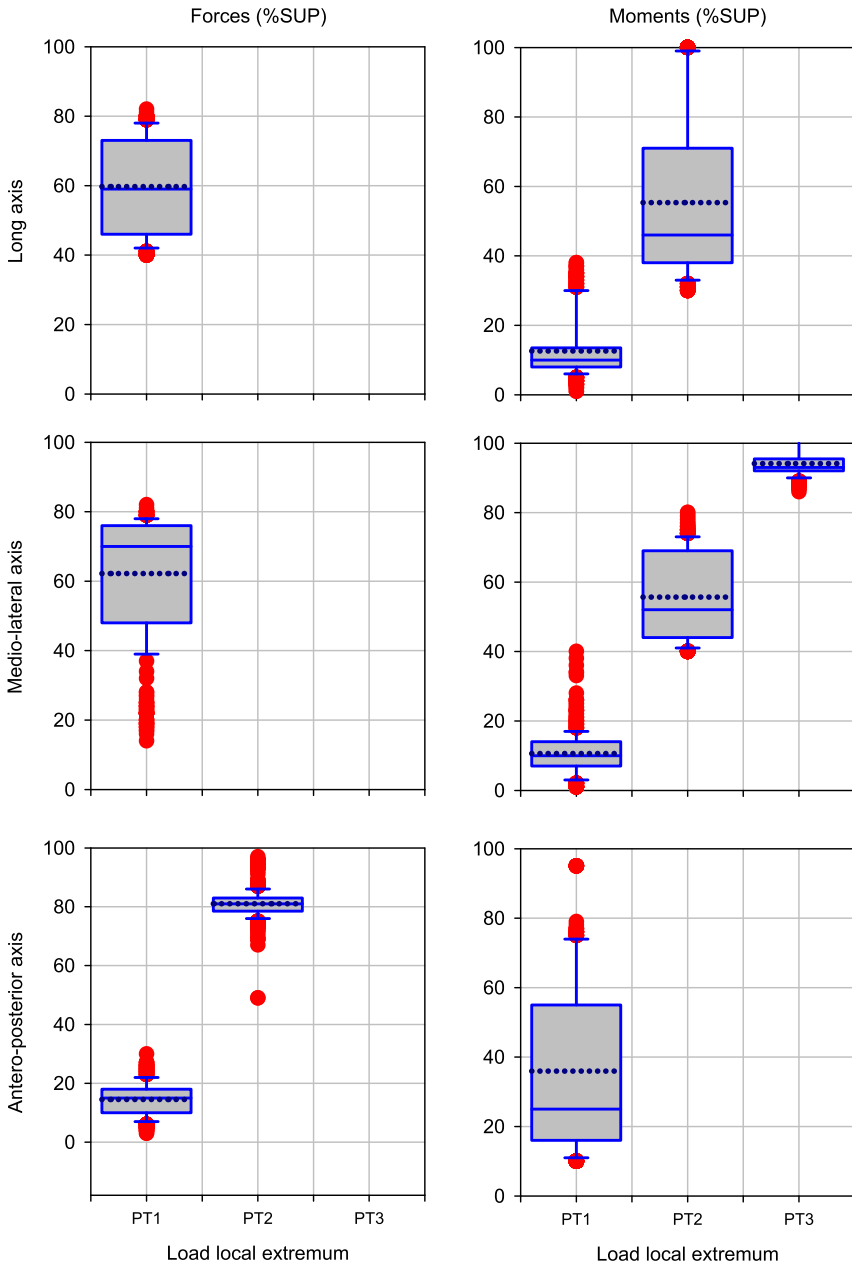


Fig. 9. Box plots showing low and high 95% confidence interval, mean and outliers of the onset expressed in percentage of support phase (%SUP) of up to three local extremum (PT1, PT2, PT3) of forces and moments applied with basic components during ascending ramp.

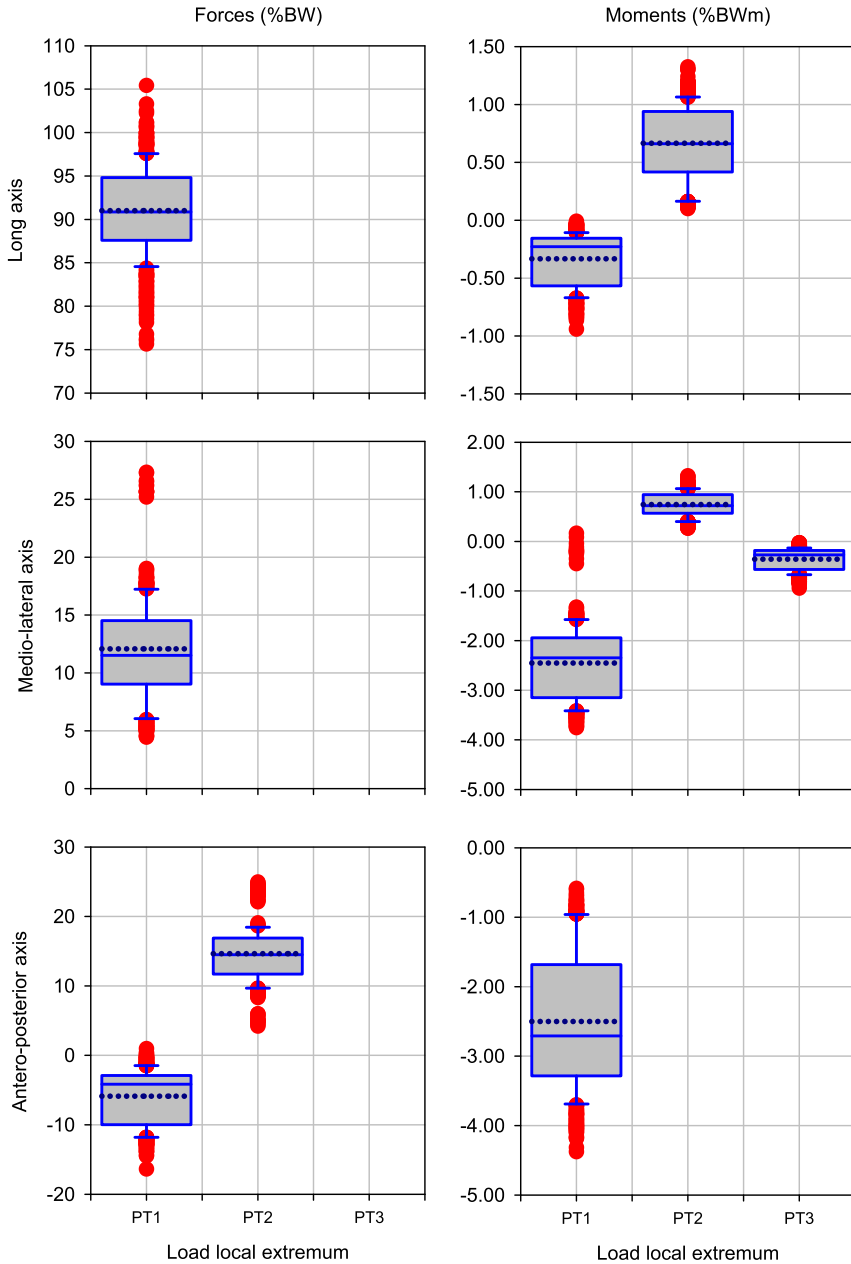


Fig. 10. Box plots showing low and high 95% confidence interval, mean and outliers of the magnitude expressed in percentage of bodyweight (%BW, %BWm) of up to three local extremum (PT1, PT2, PT3) of forces and moments applied with basic components during ascending ramp.

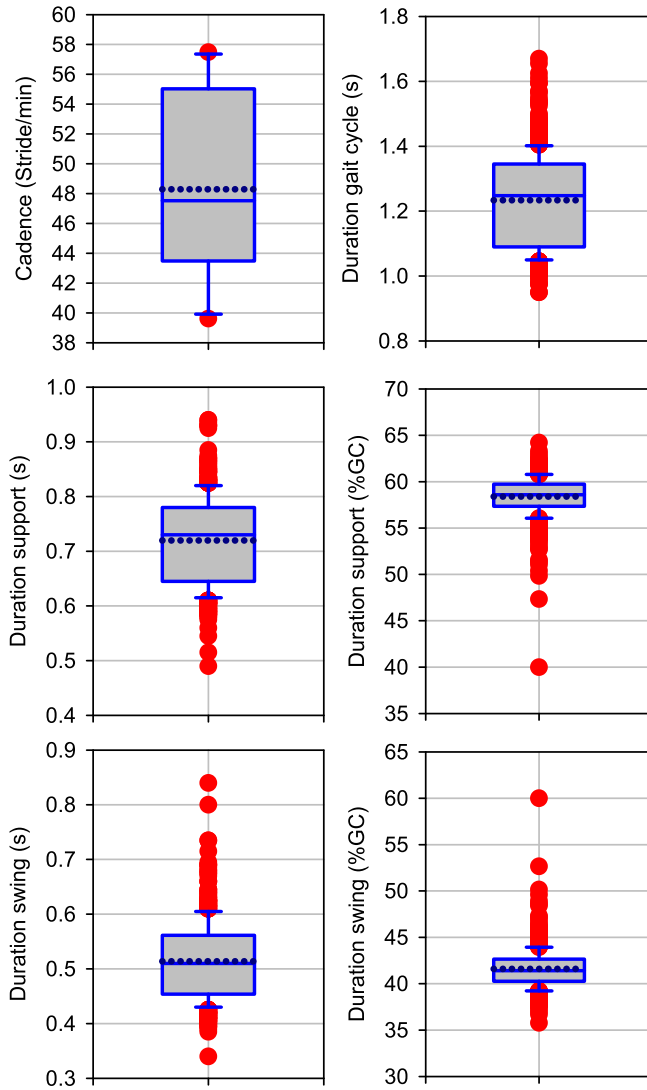


Fig. 11. Box plots showing low and high 95% confidence interval, mean and outliers of the spatio-temporal gait characteristics including cadence, duration of gait cycle (GC) as well as support and swing phases when fitted with basic components during descending ramp.

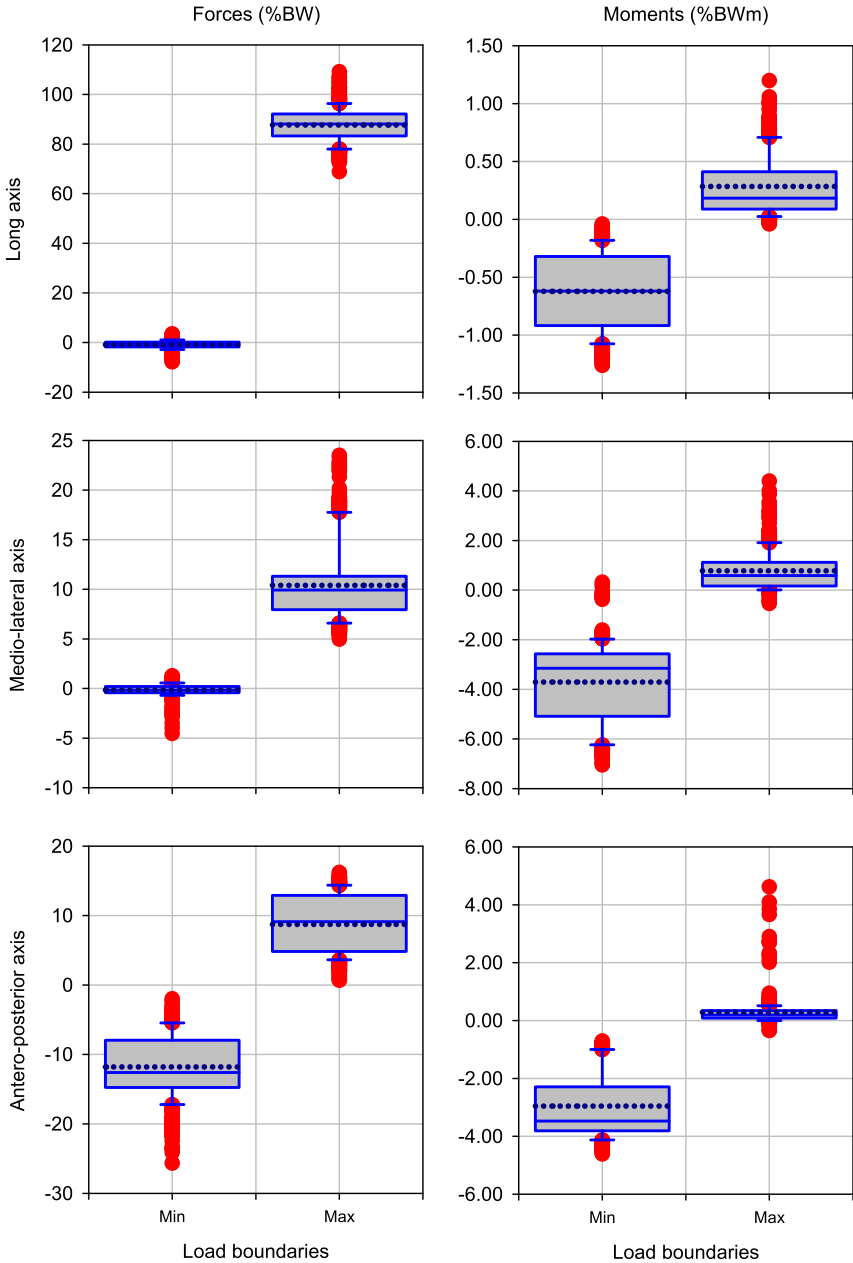


Fig. 12. Box plots showing low and high 95% confidence interval, mean and outliers of the loading boundaries including minimum (Min) and maximum (Max) of forces and moments applied when fitted with basic components during descending ramp.

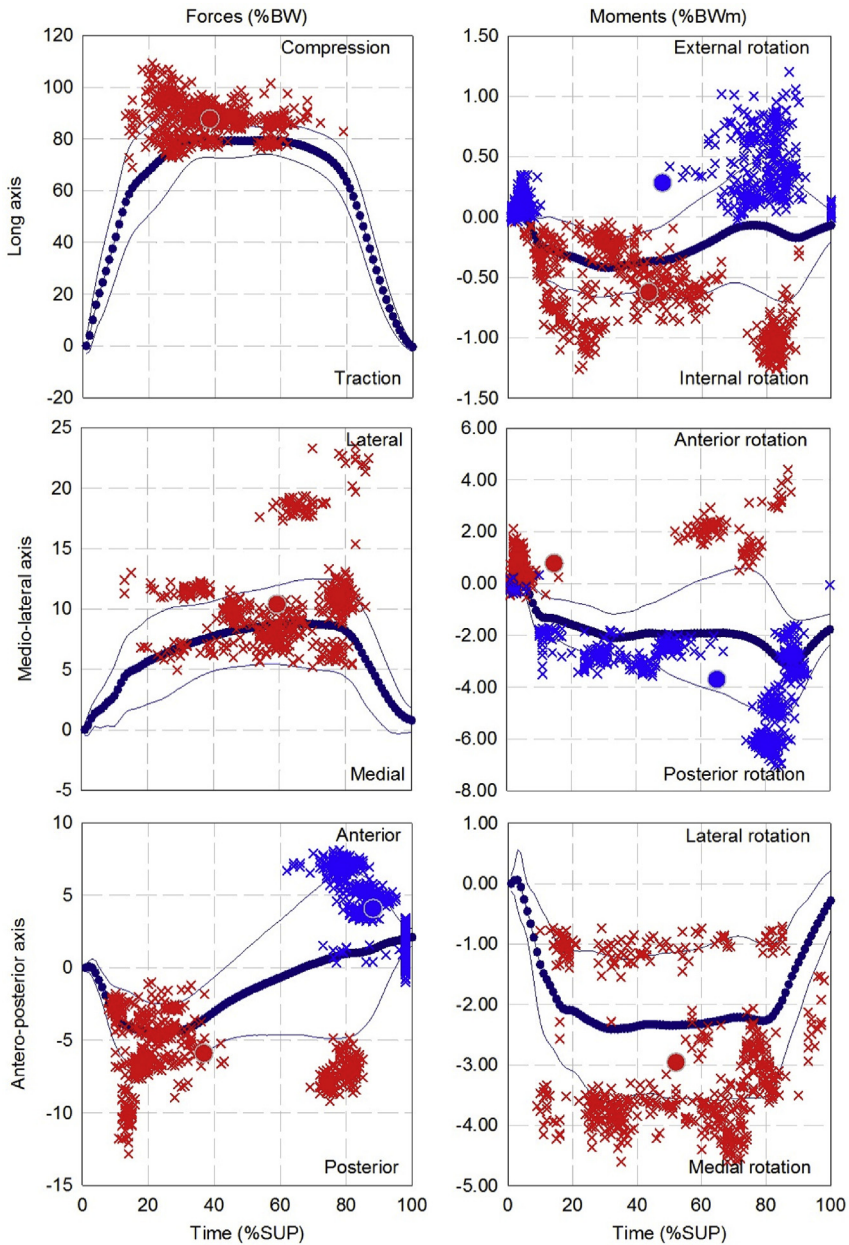


Fig. 13. Mean and standard deviation of the pattern as well as dispersion (cross) and mean (circle) for first (red) and second (bleu) local extremum of forces and moments for cohort of participants fitted with basic components during descending ramp (N = 566 gait cycles).

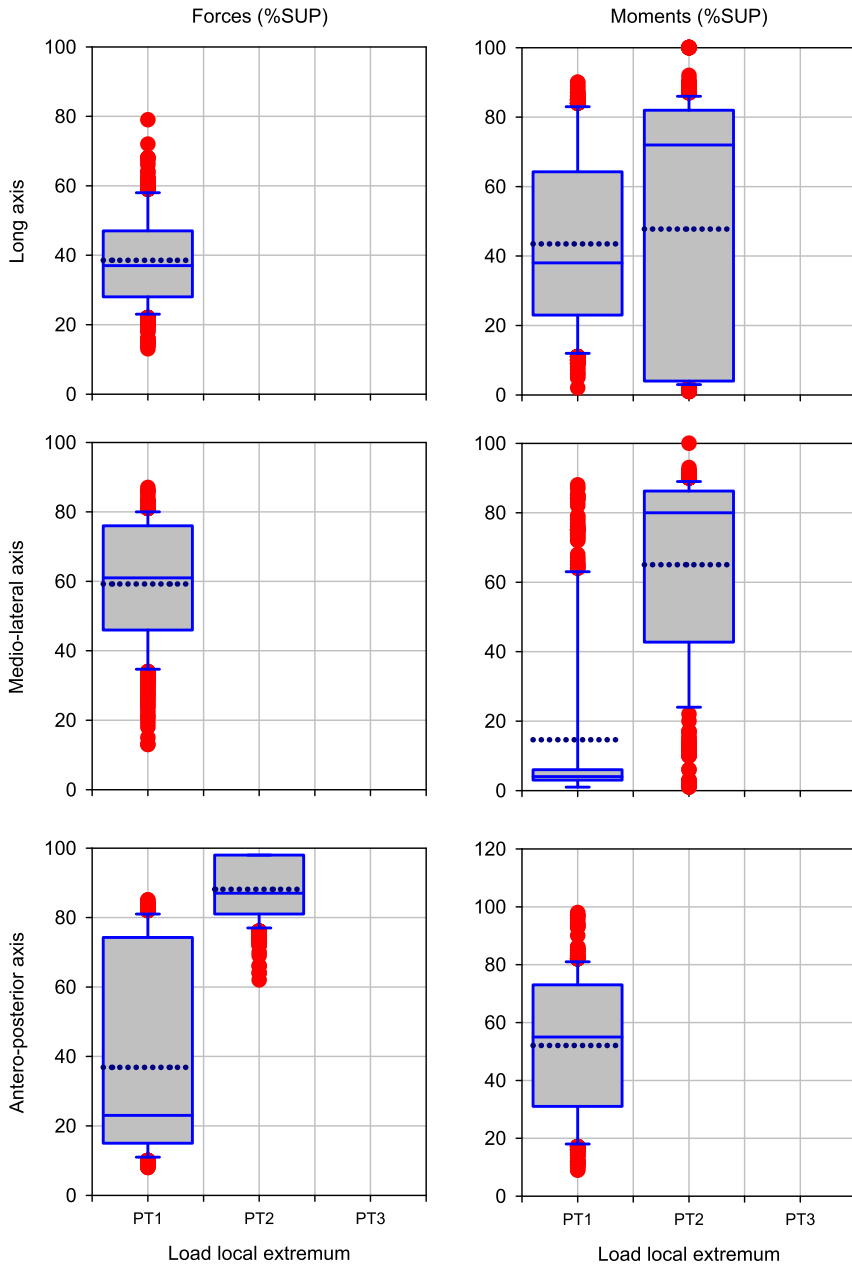


Fig. 14. Box plots showing low and high 95% confidence interval, mean and outliers of the onset expressed in percentage of support phase (%SUP) of up to three local extremum (PT1, PT2, PT3) of forces and moments applied with basic components during descending ramp.

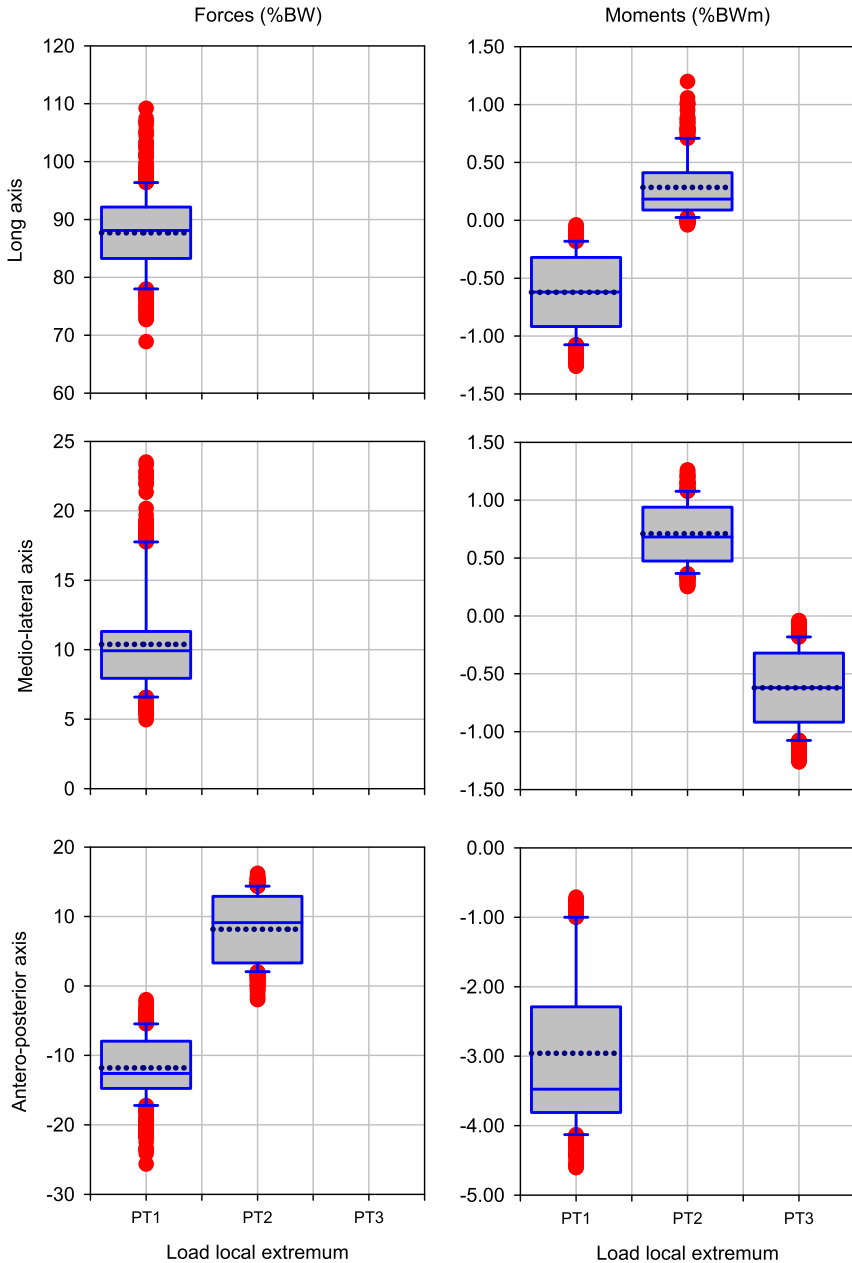


Fig. 15. Box plots showing low and high 95% confidence interval, mean and outliers of the magnitude expressed in percentage of bodyweight (%BW, %BWm) of up to three local extremum (PT1, PT2, PT3) of forces and moments applied with basic components during descending ramp.

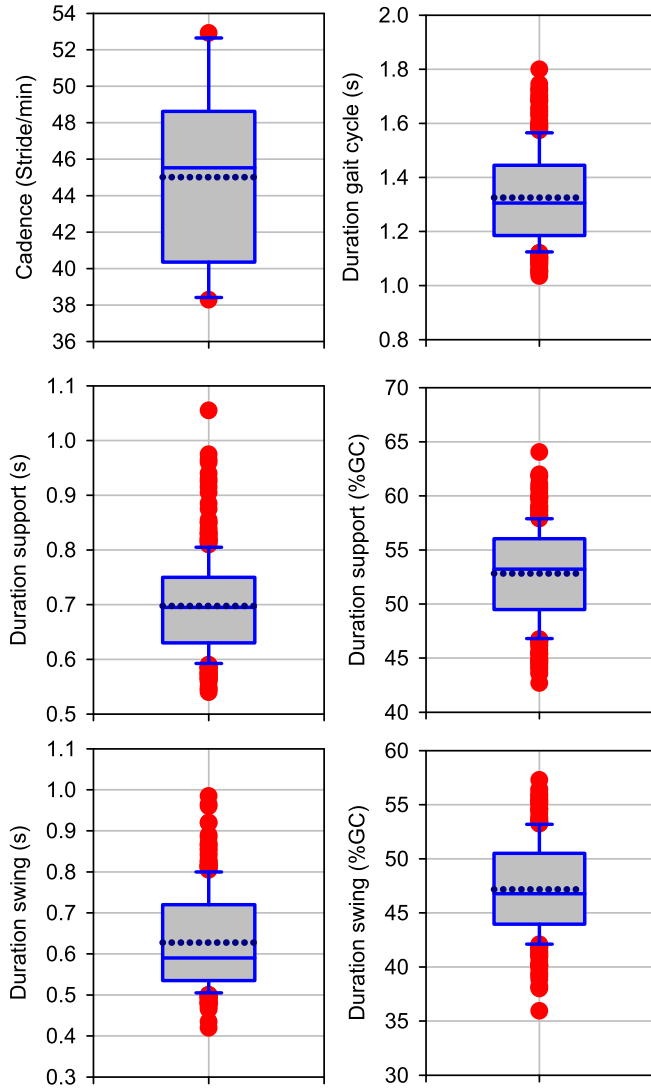


Fig. 16. Box plots showing low and high 95% confidence interval, mean and outliers of the spatio-temporal gait characteristics including cadence, duration of gait cycle (GC) as well as support and swing phases when fitted with basic components during ascending stairs.

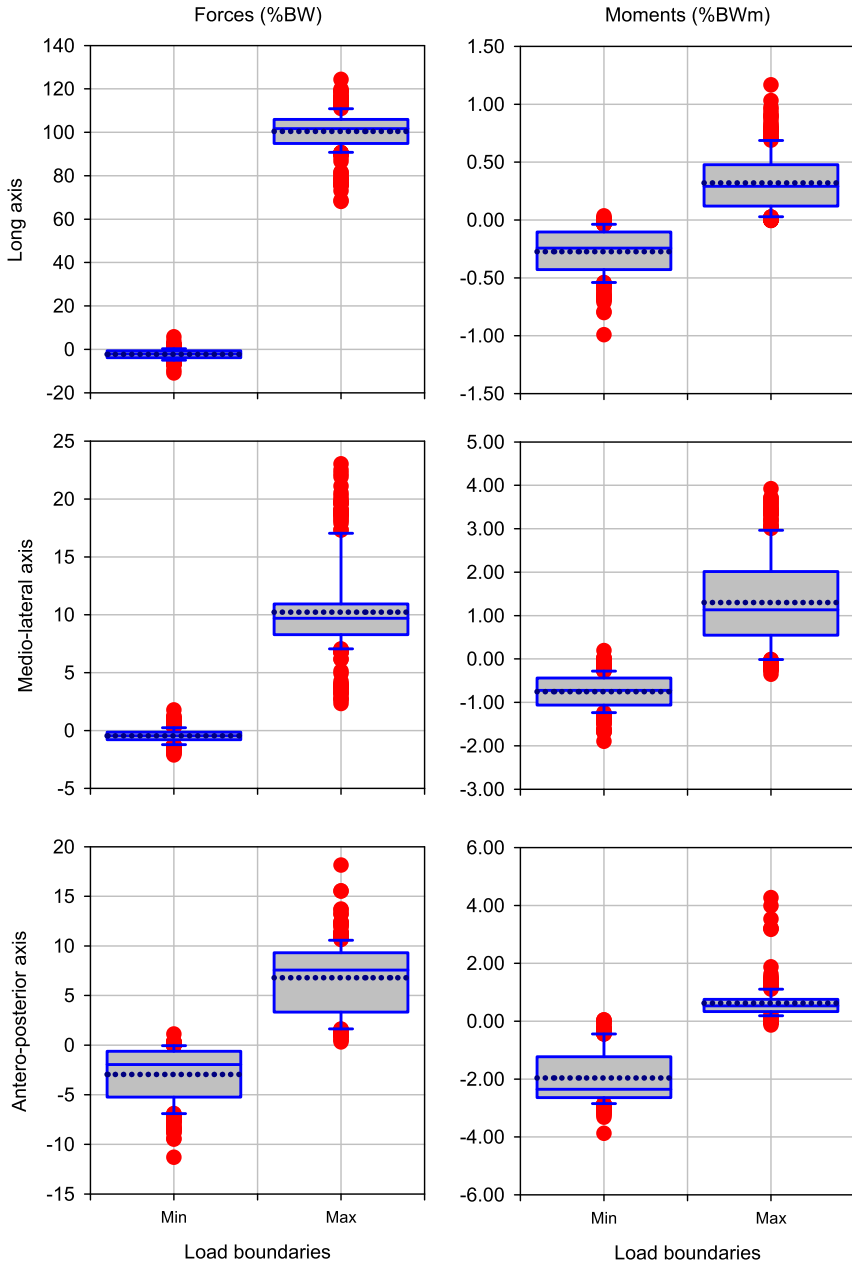


Fig. 17. Box plots showing low and high 95% confidence interval, mean and outliers of the loading boundaries including minimum (Min) and maximum (Max) of forces and moments applied when fitted with basic components during ascending stairs.

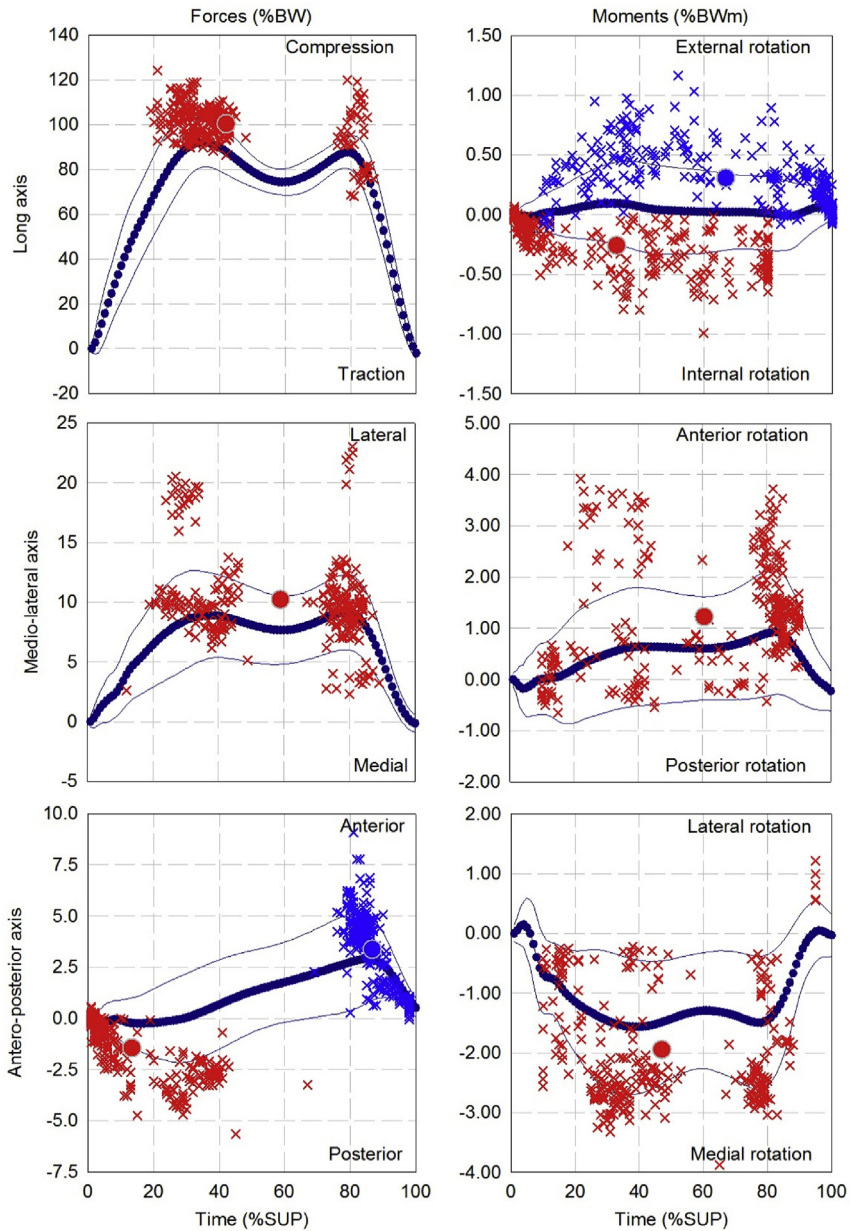


Fig. 18. Mean and standard deviation of the pattern as well as dispersion (cross) and mean (circle) for first (red) and second (bleu) local extremum of forces and moments for cohort of participants fitted with basic components during ascending stairs (N = 284 gait cycles).

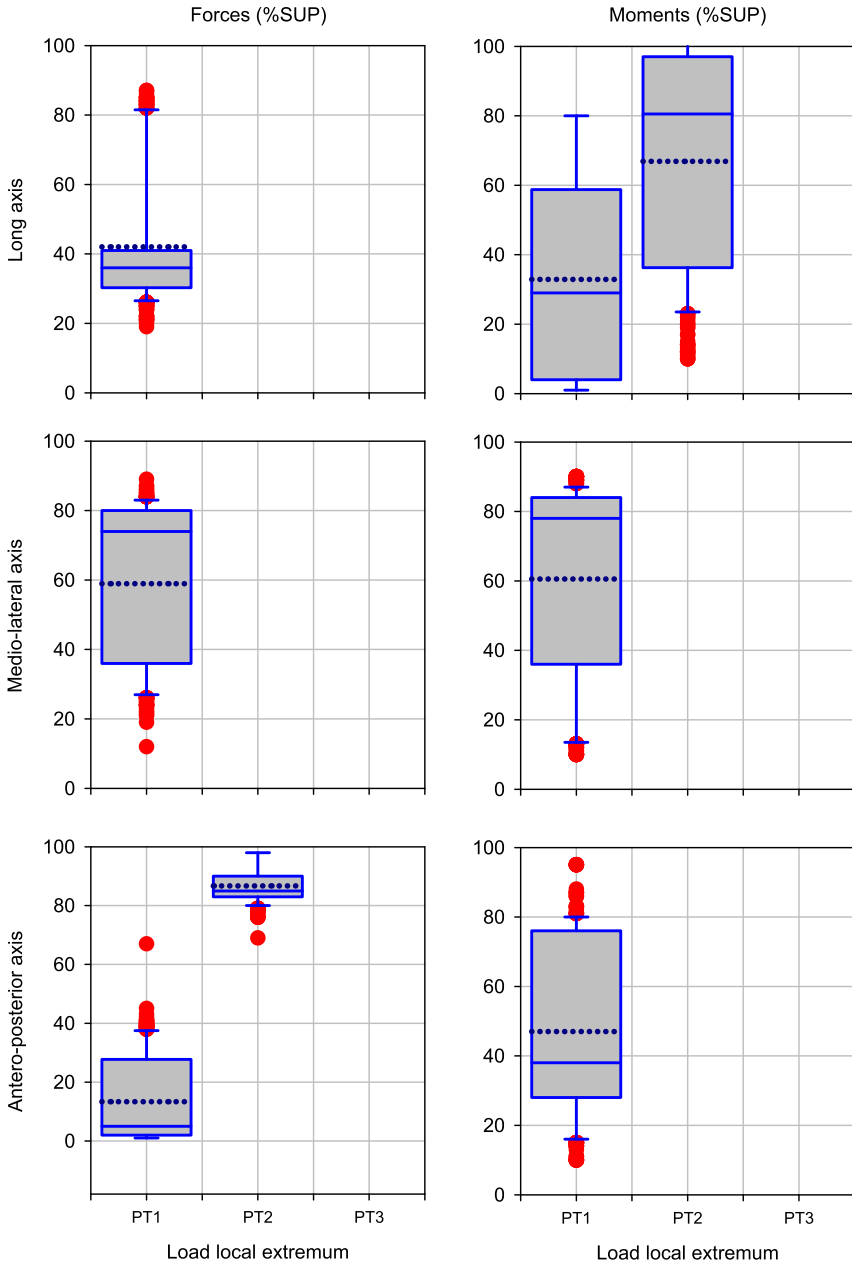


Fig. 19. Box plots showing low and high 95% confidence interval, mean and outliers of the onset expressed in percentage of support phase (%SUP) of up to three local extremum (PT1, PT2, PT3) of forces and moments applied with basic components during ascending stairs.

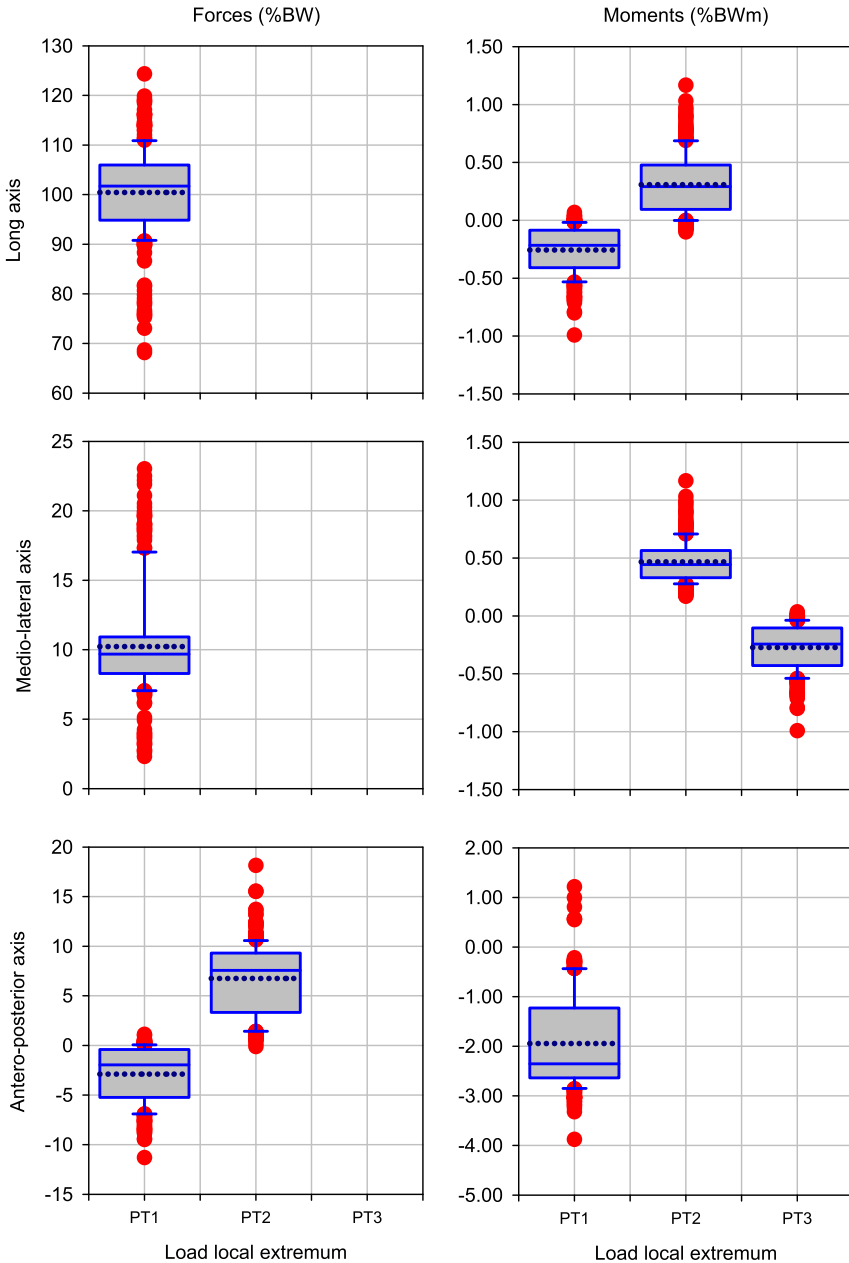


Fig. 20. Box plots showing low and high 95% confidence interval, mean and outliers of the magnitude expressed in percentage of bodyweight (%BW, %BWm) of up to three local extremum (PT1, PT2, PT3) of forces and moments applied with basic components during ascending stairs.

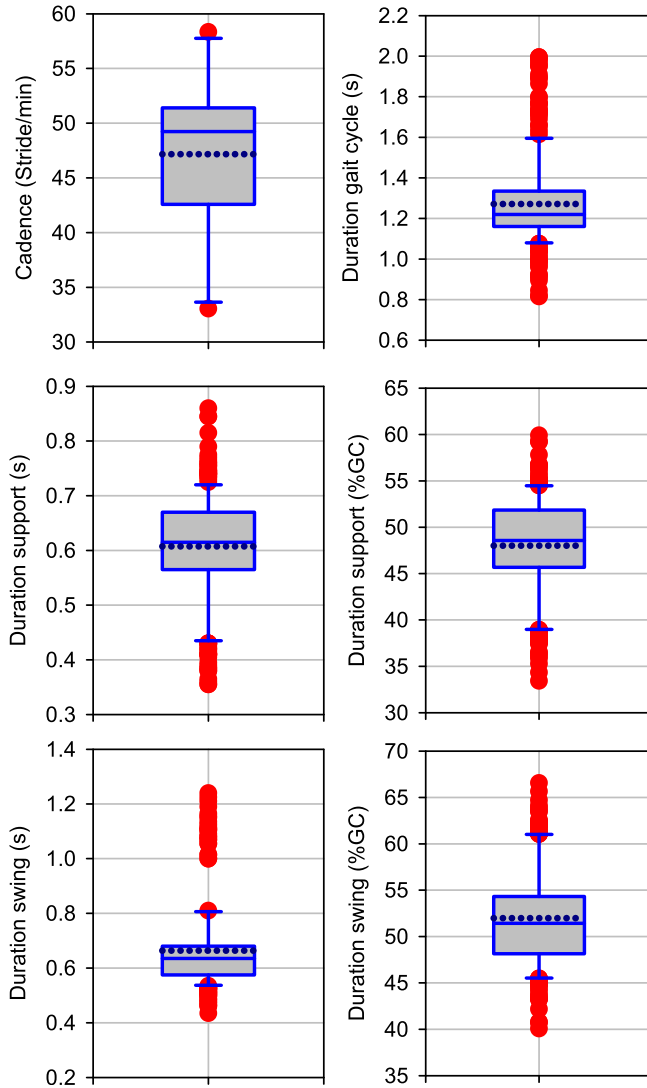


Fig. 21. Box plots showing low and high 95% confidence interval, mean and outliers of the spatio-temporal gait characteristics including cadence, duration of gait cycle (GC) as well as support and swing phases when fitted with basic components during descending stairs.

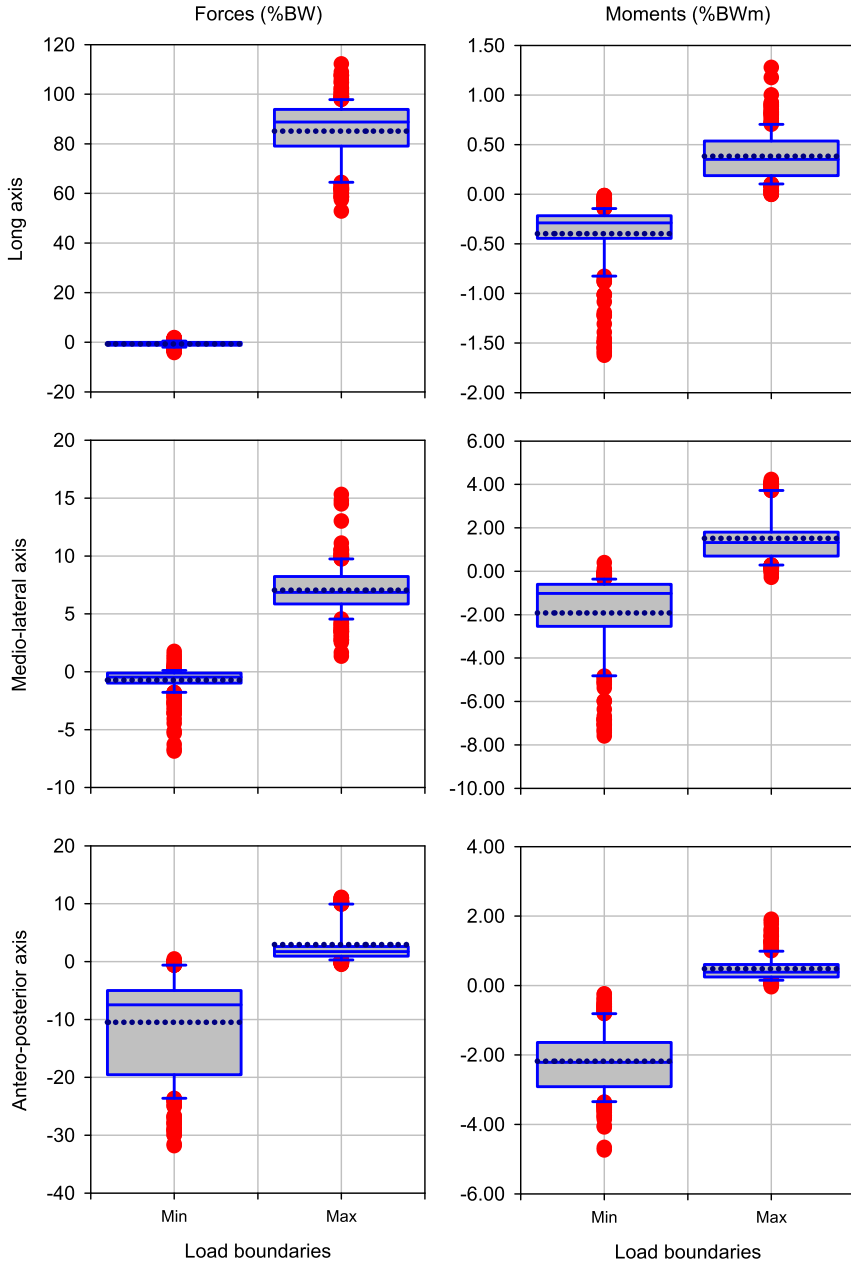


Fig. 22. Box plots showing low and high 95% confidence interval, mean and outliers of the loading boundaries including minimum (Min) and maximum (Max) of forces and moments applied when fitted with basic components during descending stairs.

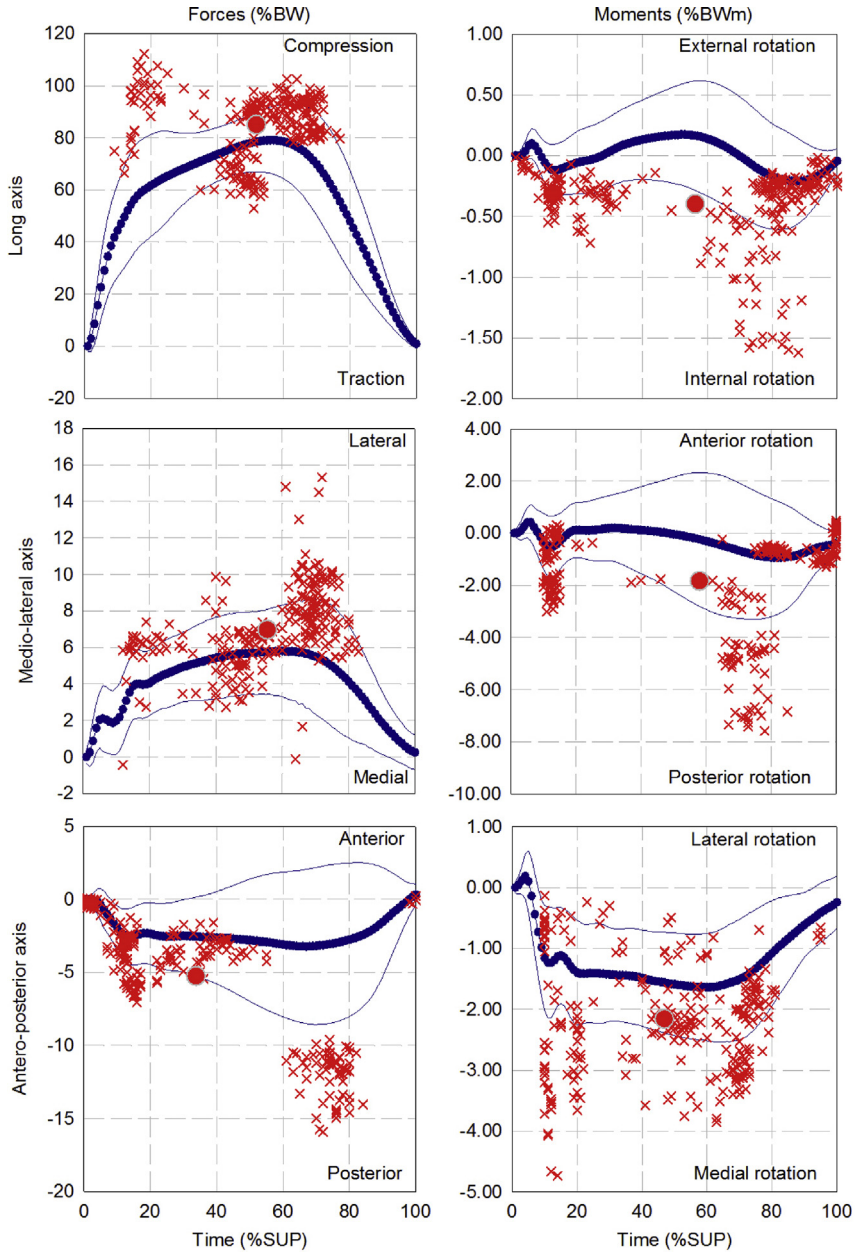


Fig. 23. Mean and standard deviation of the pattern as well as dispersion (cross) and mean (circle) for first (red) local extremum of forces and moments for cohort of participants fitted with basic components during descending stairs (N = 253 gait cycles).

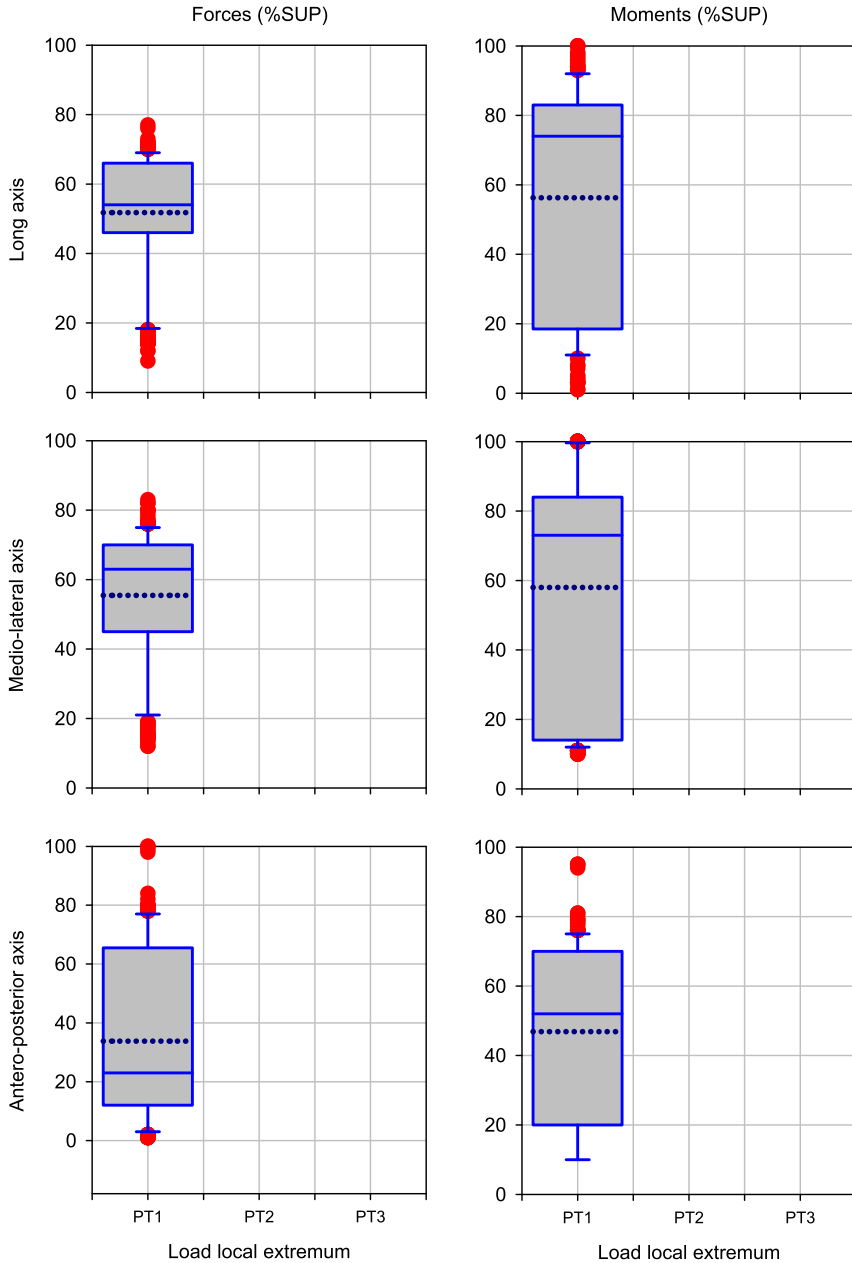


Fig. 24. Box plots showing low and high 95% confidence interval, mean and outliers of the onset expressed in percentage of support phase (%SUP) of up to three local extremum (PT1, PT2, PT3) of forces and moments applied with basic components during descending stairs.

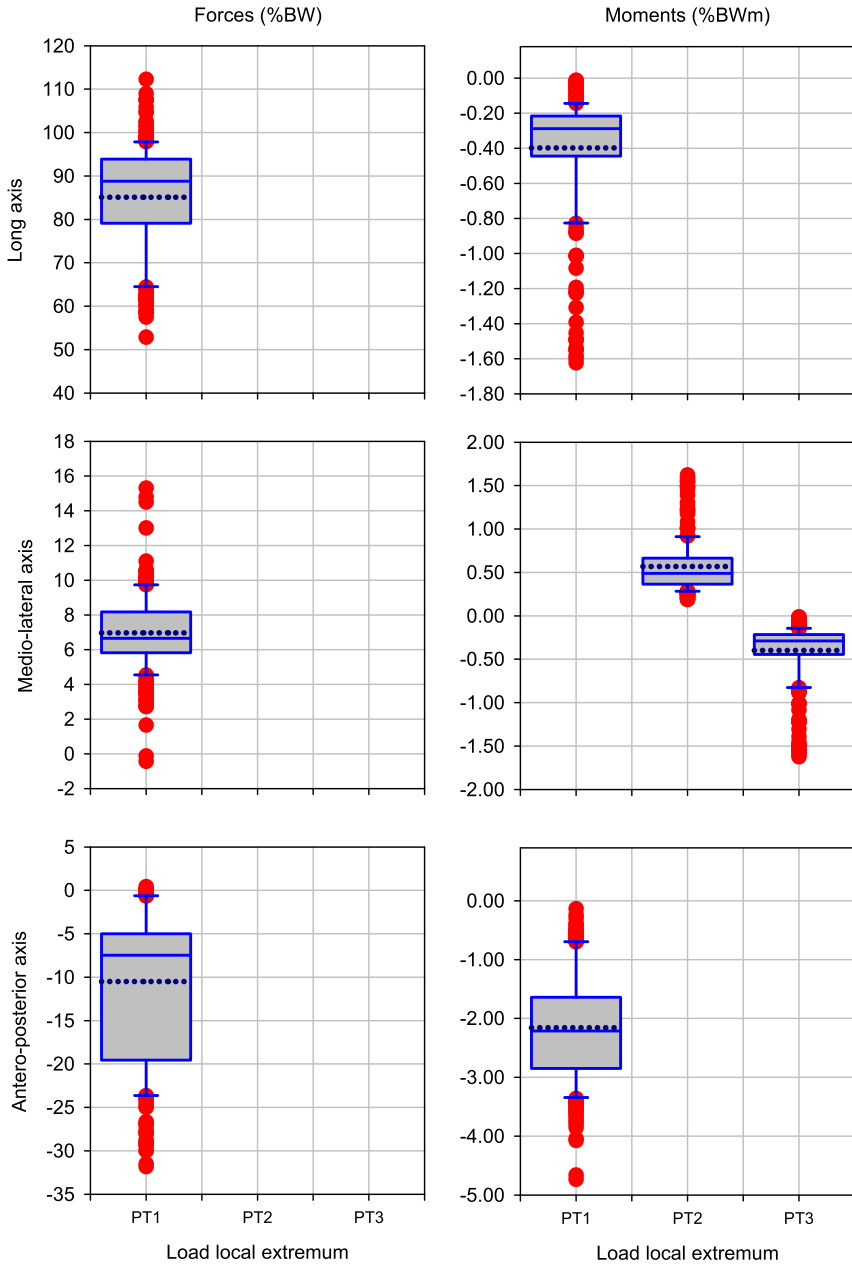


Fig. 25. Box plots showing low and high 95% confidence interval, mean and outliers of the magnitude expressed in percentage of bodyweight (%BW, %BWm) of up to three local extremum (PT1, PT2, PT3) of forces and moments applied with basic components during descending stairs.

the box plot showing low and high 95% confidence interval, mean and outliers were created using SigmaPlot 11.

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Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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