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Dataset of walking and running biomechanics with different step widths across different speeds

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The mediolateral distance between both heels at first contact is known as step width, defined as a frontal plane spatial variable. Short-term variations in step width during walking and running may impact the lower-limb biomechanics in all three planes. Considering these features, the proposed dataset of this study was established on 13 healthy young males aged between 20 and 24 years within the normal BMI range, providing data in raw ready for use for the community. In laboratory conditions, participants were required to locomote (walk and run) at six different step widths while walking at a preferred speed, running at 3.0 m/s, and running at 3.7 m/s. This dataset could expand the population sample size of similar relevant datasets and provide the data basis for future exploring on the effect of acute step width changes on the kinematic and kinetic chain in human lower at different movement speeds.

Background & Summary

Spatial and temporal variables primarily influence human locomotion. Altering the spatial or temporal aspects of running and walking activities may change the lower extremity biomechanics and related gait patterns[1]. As a result, alterations in spatiotemporal parameters that affect gait may impact several biomechanical elements linked to injuries sustained during typical locomotive activities[2–4]. Step width is a spatial variable in the frontal plane, defined as the mediolateral distance between the heel of bilateral feet at initial contact[5]. Short-term variations in step width during walking and running may impact the lower-limb biomechanics in all three planes[6–8].

As documented in the literature, whether running, walking, sprinting, ascending, or descending stairs, the change in step width as an essential gait parameter affects the kinematics and kinetics of the lower limb joints[5–7,9–12]. During running, narrow step width increased the peak rearfoot eversion and the peak rearfoot inversion moment[5,6]; knee internal rotation showed higher variation in the narrow steps than the preferred normal step width, which was similarly observed in the peak knee abduction moment and impulse[5,13]; in the hip joint, a wide step width reduced the average hip adduction angle compared to preferred step width[5,13]. While adjusting the step width during walking, the hip kinematics showed similar alterations with running, but with a lower range of hip adduction motion than in narrow or preferred step width[14,15]. In addition, under the condition of reducing the walking step width to a narrow base, the variability of the center of mass (COM) and the variability of COM velocity increased, compared to the preferred step width[16–19]. This alteration may indicate that the narrow step width increased the demand for active postural control and posed more significant risks to stability[20,21]. During walking, step width would influence the lower-limb joint kinetics[22–26]. In the frontal plane, the increased step width decreased peak knee adduction moment, knee adduction moment angular impulse, and peak hip adduction moment[24–26]. Furthermore, Meardon *et al.* found that the tibia was primarily loaded as the step width narrowed, and iliotibial band strain and strain rate increased linearly as the step width narrowed[22,23]. Consequently, changing step width during typical locomotive activities may be an effective and straightforward gait modification that would reduce joint loadings and pain and prevent potential sports injuries.

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Previous studies reported that walking and running speeds could affect lower limb biomechanical parameters[27–30]. Previous studies also presented the biomechanical profile of healthy humans at different walking and running speeds[31–34]. The authors conducted a systematic literature check and reported the state of current open-source, available gait biomechanics datasets, as summarized in Table 1.

By reviewing the previous gait datasets, there are only a few datasets about changing step width at different locomotion speeds. The gait dataset published by Van der Zee *et al.*[34] only included different step widths at a single constant walking speed. Considering the important influence of step width on the kinetic chain and stability of human lower limbs, we collected this dataset, aiming to offer more scientific and comprehensive data concerning human motion under various speeds and step width conditions. The potential effects of simple gait adjustment on athletic competition, clinical rehabilitation, pain management, and balance control can be explored through further use of this dataset[35]. The proposed dataset was established on 13 healthy young males aged between 20 and 24 years with a normal BMI range, providing the dataset in C3D, MOT, TRC, and CSV files for the application in future analysis. In laboratory conditions, participants were required to locomote at six different step widths (preferred step width, preferred step width with reduced 13% leg length, preferred step width with reduced 6.5% leg length, preferred step width with increased 25% leg length, preferred step width with increased 13% leg length, preferred step width with increased 6.5% leg length) in three different locomotion modes (walking at preferred speed, running at 3.0 m/s, and running at 3.7 m/s), which is not present in the previous gait dataset provided. Thus, this dataset could expand the population sample size of related datasets and offer new insight for researchers to explore and analyze the effect of acute changes in step width on the kinetic chain of human lower limbs at different movement speeds.

Methods

Participants. Thirteen male participants of Chinese ethnicity (age: 22.7 ± 1.6 years, body mass: 70.9 ± 8.0 kg, body height: 1.75 ± 0.5 m, detailed information presented in Table 2) were recruited to join in this project investigating the biomechanical changes in the lower extremity. All recruited runners are the right-leg dominance. The dominant side was determined as the preferred leg of ball-kicking during participant inclusion[36], as the dominant limb of the same side could avoid inter-limb discrepancy and asymmetry[37,38]. All participants were free from lower extremity injuries or foot deformities in the past six months before the test. The study was approved by the ethics committee from the Research Institute at Ningbo University (ty2022001). Written consent was obtained from all participants, and they were informed of the objectives, procedures, and requirements of this running test. All participants agreed with the publication of the dataset.

Instruments. An eight-camera Vicon Motion capture system (Vicon Metrics Ltd., Oxford, UK) at 200 Hz was used to track the three-dimensional (3D) trajectories of 38 cutaneous reflective markers placed on anatomical landmarks and clusters. The 38 makers are shown in Fig. 1 and Table 3. The motion capture system (Vicon Metrics Ltd., Oxford, UK) synchronizes the two embedded force platforms (AMTI, Watertown, MA, United States, and Kistler, Winterthur, Switzerland) at 1000 Hz. A single-beam electronic timing gate (Brower Timing Systems, Draper, UT, USA) was placed on a tripod to record walking or running speed while the participant walked or ran across the force platform. The distance between electronic timing gates is set to 3 m. The laboratory environment is shown in Fig. 2.

Procedure. Figure 3 shows the experiment procedure. The entire data collection was performed for each participant in a session lasting approximately two hours. Three researchers managed all sessions. The following procedure was adopted.

(1) Introduction to the participant: The operator presented the laboratory, described why the database was needed, and briefly detailed how the experiment was run, including the materials utilized. The participant was free to ask questions at any time.
(2) Preparation of the participant: Participants were asked to remove excess clothing, and only sports shorts were left. Standard lab shoes were worn by all participants to avoid the impact of footwear on gait[39]. The researchers collected anthropometric data (i.e., height, body mass, leg length, shoulder width, and iliac width) from each participant. Specialized researchers attached 38 reflective markers onto the skin surface using double-sided adhesive based on the anatomical landmarks of the participants. Before conducting the static and dynamic experiments, participants were asked to do a 5-minute jog for warm-up[40].
(3) Static record: The participants were asked to stand upright for 10 seconds, with straight legs and their feet spread out shoulder width apart, and one foot standing on the middle of the force platform, arms extended parallel to their shoulders, looking straight ahead. The verbal instruction was: "Spread your arms slightly and stay in a static position for 10 seconds without moving". The operator verified the record. A new standing trial was conducted if a missing marker or movements disrupted the record.
(4) Preferred step widths trials: First, the participants were asked to walk and run on a straight instrumented path with two force platforms.
During the walk, the left foot steps on force platform A (Kistler, Winterthur, Switzerland), and the right foot steps on force platform B (AMTI, Watertown, MA, United States). The distance between the timing gates is 3 m. The instruction was "to walk as naturally as possible, looking forward." Then, similarly, the participants were asked to run on a straight instrumented path with two force platforms at 3.0 m/s. The electronic timing gates recorded the speed, and the trial was considered successful if the time of running through the force platform was between 0.95 and 1.05 seconds. Finally, the participants were asked to run on a straight instrumented path with two force platforms at 3.7 m/s; the trial is considered successful if the time of running through the force platform is between 0.76 and 0.86 s.

Study	Participant	Age (years)	Walk	Run	Step length	Step frequency	Step width	Stair Ascent	Stair Descent	Incline	Decline	Technology	Data formats	GRF	Trajectories
Moore *et al.*[47]	4 females, 11 males	24 ± 4	0.8 m/s, 1.2 m/s, 1.6 m/s									Treadmill (Forcelink, Culemborg, Netherlands), 10 Osprey camera motion capture system paired with the Cortex 3.1.1.1290 software (Motion Analysis, Santa Rosa, CA, USA)	TSV		47 makers
Fukuchi *et al.*[31]	28 adults	19–51		2.5 m/s, 3.5 m/s, 4.5 m/s								12 cameras having 4 Mb of resolution and the Cortex 6.0 software (Raptor-4, Motion Analysis, Santa Rosa, CA, USA), dual-belt treadmill (FIT, Bertec, Columbus, OH, USA).	C3D ASCII	YES	48 markers
Fukuchi *et al.*[31]	24 young adults, 18 older adults	27.6 ± 4.4 62.7 ± 8.0	40%, 55%, 70%, 85%, 100%, 115%, 130%, 145% of the self-selected speed.									motion-capture system with 12 cameras (Raptor-4; Motion Analysis Corporation, Santa Rosa, CA, USA), 5 force platforms (three 40 × 60-cm Optima models; AMTI, Watertown, MA, USA; two 40 × 60-cm 9281EA models; Kistler, Winterthur, Switzerland), a dual-belt, instrumented treadmill (FIT; Bertec, Columbus, OH, USA)	C3D ASCII	YES	26 anatomical reflective markers
Hu *et al.*[48]	7 males, 3 females	25.5 ± 2						4-step staircase	4-step staircase	10°	10°	bipolar surface electrodes (DE2.1; Delsys, Boston, MA, USA), electrogoniometers (SG150; Biometrics Ltd., Newport, UK)	CSV MVC	NO	NO
Lencioni *et al.*[49]	25 males, 25 females	6–72	natural speed, increase and decrease raw speed.					2-step staircase	2-step staircase			9-camera motion capture system (SMART system, BTS, Garbagnate Milanese, Italy), 2 force platforms (Kistler, Winterthur, Switzerland), and an 8-channel wireless EMG recording system (ZeroWirePlus, Cometa, Bareggio, Italy).	MAT	YES	29 retro-reflective markers
Schreiber *et al.*[32]	26 males, 24 females	37.0 ± 13.6	0–0.4 m/s, 0.4–0.8 m/s, 0.8–1.2 m/s, self-selected spontaneous and fast speeds									10-camera optoelectronic system sampled at 100 Hz (OQUS4, Qualisys, Sweden), 2 forceplates sampled at 1500 Hz (OR6-5, AMTI, USA), surface electromyographic (EMG) system sampled at 1500 Hz (Desktop DTS, Noraxon, USA)	C3D	YES	52 reflective markers

Continued

Study	Participant	Age (years)	Walk	Run	Step length	Step frequency	Step width	Stair Ascent	Stair Descent	Incline	Decline	Technology	Data formats	GRF	Trajectories
Camargo *et al.*[50]	13 males, 9 females	21 ± 3.4	0.5 to 1.85 m/s in 0.05 m/s increments					6-step staircase at 4 stair heights: 102 mm,127 mm, 152 mm, 178 mm	6-step staircase at 4 stair heights: 102 mm, 127 mm, 152 mm, 178 mm	5.2°, 7.8°, 9.2°, 11°, 12.4°, 18°	5.2°, 7.8°, 9.2°, 11°, 12.4°, 18°	EMG (Biometrics. Ltd. Newport, UK), goniometers (Biometrics. Ltd. Newport, UK), six-axis inertial measurement units (Yost, Ohio, USA), and bilaterally with 32 motion capture markers (Vicon. Ltd., Oxford, UK), force plates (Bertec, Ohio, USA)			32 motion capture markers
Moreira *et al.*[33]	8 males, 8 females	23.8 ± 2.02	1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0 km/h									EMG system (Trigno - Delsys, Massachusetts, United States of America), motion-capture system with 12 cameras (Oqus, Qualisys – Motion-Capture System, Göteborg, Sweden), 6 force platforms (Bertec, Ohio, United States of America), (Bertec, Ohio, United States of America), (Kistler, Winterthur, Switzerland).	ASCII C3D MAT	YES	24 retro-reflective markers
Reznick *et al.*[51]	5 males, 5 females	30.4 ± 14.9	0.8 m/s, 1 m/s, 1.2 m/s	1.8 m/s, 2 m/s, 2.2 m/s, 2.4 m/s				4-step staircase and the inclines (20, 25, 30, 35) correspond with riser heights of 3.81, 4.72, 5.75, and 6.38in.	4-step staircase and the inclines (20, 25, 30, 35) correspond with riser heights of 3.81, 4.72, 5.75, and 6.38in.	0°, 5°, 10°	0°, 5°, 10°	10-camera Vicon T40 motion capture system (Vicon, Oxford, UK), Bertec instrumented split-belt treadmill (Bertec Corporation, Columbus, OH), force plates, and 4-Step Adjustable Stair Set (Staging Dimensions, Inc., New Castle, Delaware).	MAT README	YES	14 markers
Mei *et al.*[46]	20 males	25.8 ± 1.6		pre and post a 5 km treadmill run								Vicon Motion capture system (Vicon Metrics Ltd., Oxford, UK), an embedded AMTI force platform (AMTI, Watertown, MA, United States)	C3D MAT		
Van der Zee *et al.*[34]	10 young adults	23.5 ± 2.5	0.7 m/s,0.9 m/s,1.10 m/s, 1.25 m/s,1.40 m/s,1.60 m/s, 1.80 m/s, 2.0 m/s		0.5–1.1 m	0.56–1.28 f	0–0.4 m					two force platforms (Bertec, Columbus, OH, USA), a custom split-belt treadmill, 3D system (Motion Analysis Corporation, Santa Rosa, CA, USA),	C3D MDH CMO MAT	YES	37 markers

Continued

Study	Participant	Age (years)	Walk	Run	Step length	Step frequency	Step width	Stair Ascent	Stair Descent	Incline	Decline	Technology	Data formats	GRF	Trajectories
Grouvel *et al.*[52]	6 males, 4 females	29.7 ± 6.4	comfortable speed, slow speed, fast speed	spontaneous speed without sprinting								12-camera optoelectronic system (Oqus 7 +, Qualisys, Göteborg, Sweden), 3 force plates sampled at 1000 Hz (AMTI Accugait, Watertown, MA, USA), 8 IMUs (Physilog6S, GaitUp, Renens, Switzerland), Two insoles (Insole3, Moticon ReGo AG, Munich, Germany)	C3D ASCII BIN CSV	YES	69 reflective markers
Scherpereel *et al.*[53]	7 males, 5 females	21.8 ± 3.2	0.4 m/s, 0.6 m/s, 1.2 m/s, 1.8 m/s	2.0 m/s, 2.5 m/s				152 mm at normal, slow, and fast speed	152 mm at normal, slow, and fast speed	5°, 10°	5°, 10°	Motion capture data at 200 Hz (Vicon. Ltd., Oxford, UK), an instrumented treadmill (Bertec Corporation, Columbus, Ohio), ground force plates (Bertec Corporation, Columbus, Ohio), Delsys trigger module (Delsys, Natick, MA), experimental sensors (Trigno Avanti Wireless EMG, Delsys, Natick, MA).	C3D CSV MAT	YES	

Table 1. Available open-source gait biomechanical datasets in the literature.

	Age	Gender	Body mass	Height	Leg length	Shoulder width	Iliac width	Pw width	Pr1 width	Pr2 width
P1	24 yrs	male	74 kg	175 cm	91 cm	35 cm	26 cm	126 mm	60 mm	64 mm
P2	24 yrs	male	72 kg	172 cm	88 cm	36 cm	25 cm	90 mm	109 mm	112 mm
P3	23 yrs	male	80 kg	178 cm	90 cm	34 cm	27 cm	163 mm	190 mm	213 mm
P4	23 yrs	male	60 kg	170 cm	83 cm	29 cm	24 cm	127 mm	123 mm	121 mm
P5	21 yrs	male	71 kg	171 cm	84 cm	32 cm	23 cm	127 mm	114 mm	115 mm
P6	20 yrs	male	65 kg	168 cm	86 cm	38 cm	28 cm	119 mm	118 mm	140 mm
P7	25 yrs	male	72 kg	176 cm	87 cm	39 cm	29 cm	135 mm	139 mm	167 mm
P8	23 yrs	male	85 kg	181 cm	90 cm	40 cm	28 cm	143 mm	131 mm	143 mm
P9	24 yrs	male	76 kg	183 cm	93 cm	40 cm	27 cm	178 mm	77 mm	81 mm
P10	20 yrs	male	80 kg	182 cm	90 cm	31 cm	29 cm	206 mm	156 mm	178 mm
P11	23 yrs	male	75 kg	175 cm	88 cm	33 cm	24 cm	157 mm	194 mm	215 mm
P12	24 yrs	male	80 kg	177 cm	91 cm	34 cm	31 cm	136 mm	113 mm	131 mm
P13	21 yrs	male	58 kg	170 cm	84 cm	34 cm	24 cm	134 mm	134 mm	137 mm

Table 2. Demographic information of participants. Notes: Pw width (preferred walking step width); Pr1 width (preferred running 1 step width); Pr2 width (preferred running 2 step width).

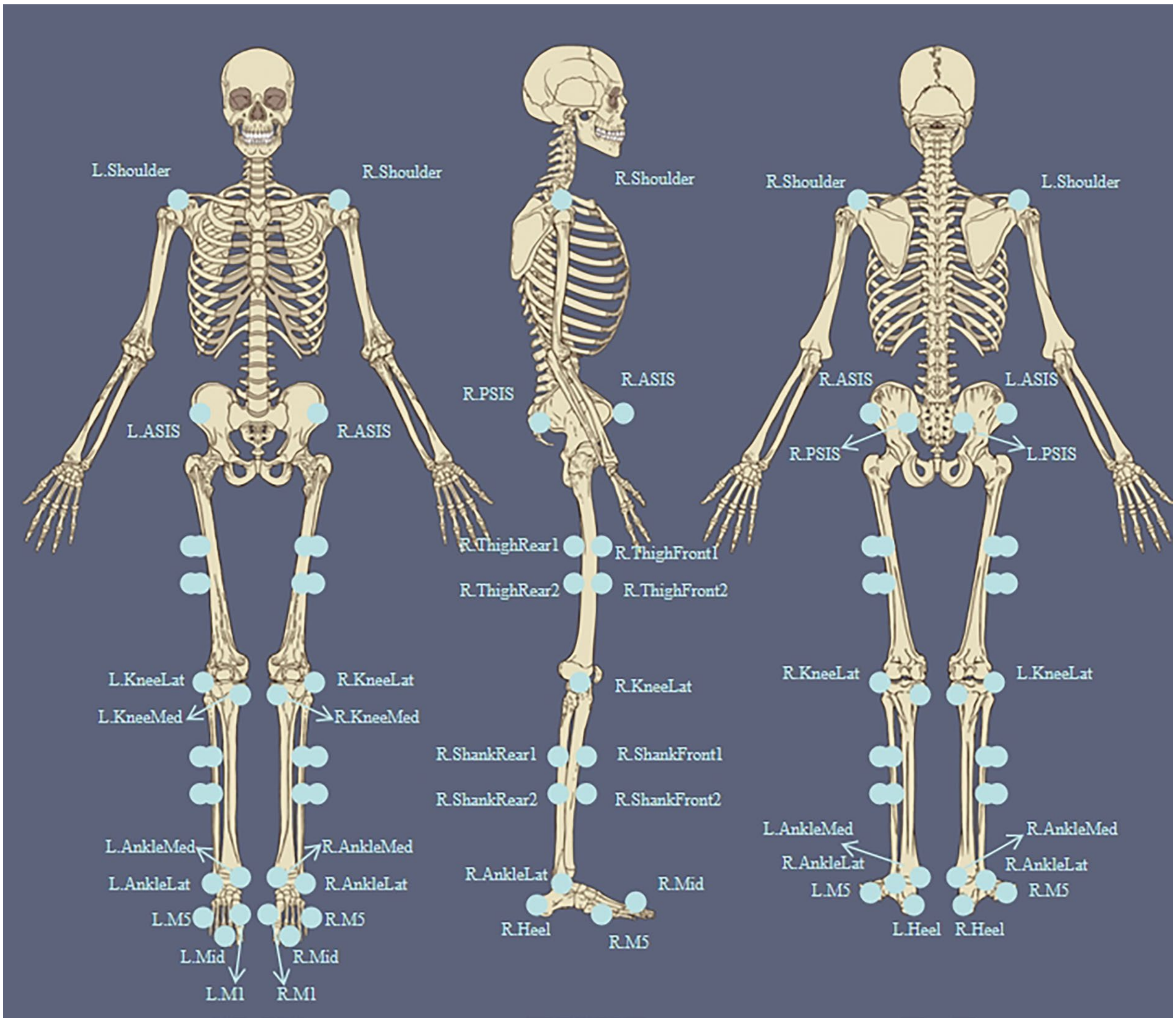

Fig. 1 Illustration of marker-set.

	Labels	Dimension	Unit	Description	Frequency (Hz)
1	R.Shoulder	3	mm	Right Acromion	200
2	L.Shoulder	3	mm	Left Acromion	200
3	R.ASIS	3	mm	Right Anterior Superior Iliac Spine	200
4	L.ASIS	3	mm	Leaf Anterior Superior Iliac Spine	200
5	R.PSIS	3	mm	Right Posterior Superior Iliac Spine	200
6	L.PSIS	3	mm	Left Posterior Superior Iliac Spine	200
7	R.ThighRear1	3	mm	Right Thigh, Upper rear	200
8	R.ThighFront1	3	mm	Right Thigh Upper front	200
9	R.ThighRear2	3	mm	Right Thigh, Lower rear	200
10	R.ThighFront2	3	mm	Right Thigh Lower front	200
11	R.KneeLat	3	mm	Lateral Epicondyle of Right Knee	200
12	R.KneeMed	3	mm	Medial Epicondyle of Right Knee	200
13	R.ShankRear1	3	mm	Right Shank Upper Rear	200
14	R.ShankFront1	3	mm	Right Shank Upper Front	200
15	R.ShankRear2	3	mm	Right Shank Lower Rear	200
16	R.ShankFront2	3	mm	Right Shank Lower Front	200
17	R.AnkleLat	3	mm	Lateral Malleoli of Right Ankle	200
18	R.AnkleMed	3	mm	Medial Malleoli of Right Ankle	200
19	R.M5	3	mm	Right Medial 5th Metatarsal Head	200
20	R.M1	3	mm	Right Later 1st Metatarsal Head	200
21	R.Mid	3	mm	Right 1st and 5st toes middle	200
22	R.Heel	3	mm	Posterior Tuberosity of Right Calcaneus	200
23	L.ThighRear1	3	mm	Left Thigh Upper rear	200
24	L.ThighFront1	3	mm	Left Thigh Upper front	200
25	L.ThighRear2	3	mm	Left Thigh Lower rear	200
26	L.ThighFront2	3	mm	Left Thigh Lower front	200
27	L.KneeLat	3	mm	Lateral Epicondyle of Left Knee	200
28	L.KneeMed	3	mm	Medial Epicondyle of Left Knee	200
29	L.ShankRear1	3	mm	Left Shank Upper Rear	200
30	L.ShankFront1	3	mm	Left Shank Upper Front	200
31	L.ShankRear2	3	mm	Left Shank Lower Rear	200
32	L.ShankFront2	3	mm	Left Shank Lower Front	200
33	L.AnkleLat	3	mm	Lateral Malleoli of Left Ankle	200
34	L.AnkleMed	3	mm	Medial Malleoli of Left Ankle	200
35	L.M5	3	mm	Left Medial 5st Metatarsal Head	200
36	L.M1	3	mm	Left Later 1st Metatarsal Head	200
37	L.Mid	3	mm	Left 1st and 5st toes middle	200
38	L.Heel	3	mm	Posterior Tuberosity of Left Calcaneus	200

Table 3. Description of markers and metadata information in the C3D files.

During the run, the left foot steps on force platform **A**, and the right foot steps on force platform **B**. The instruction was "to run as naturally as possible, looking forward." The two running speeds used in the experiment were based on previous studies, and there were noticeable biomechanical differences between the two speeds[30]. The participants were given several chances to try walking and running before the formal trial began to ensure accurate stepping on the force platform with the most natural gait during the trial. At least five successful trials were recorded for all three locomotion conditions. The trial's success was defined as (1) the participant walking and running naturally and looking forward during data collection. (2) The left foot is successfully stepped on the force platform A, and the right foot is successfully stepped on the force platform B. (3) The time passed by the electronic timing gates in the running test is within the specified range. The researchers rapidly verified all trials. (4) The reflective marking points did not fall off during data collection.

(5) Measuring the preferred step width and setting different step widths: Based on the definition of step width and previous research[5,15,23,25], researchers measured the preferred step width for participants in three other motions through previously recorded trials. Researchers determined the left and right heel (L.Heel and R.Heel) markers' position on the front plane (Y-axis) when the left foot initial contact with force platform A and the right foot initial contact with force platform B by Vicon Motion capture system (Vicon Metrics Ltd., Oxford, UK), to subtract the Y-axis coordinates of the two feet heels when they first contact the ground to calculate the preferred step width for the participant. The three successful step width trials

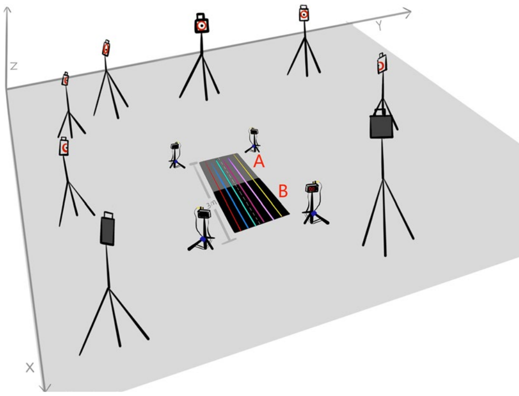

Fig. 2 Illustration of the laboratory environment and different step width conditions. Platform A (Kistler, Winterthur, Switzerland) and Platform B (AMTI, Watertown, MA, United States), Distance between Yellow and dotted line: preferred step width, Distance between Yellow and Pink: preferred step width reduce 13% personal leg length, Distance between Yellow and Purple: preferred step width reduce 6.5% personal leg length, Distance between Yellow and Green: preferred step width add 6.5% personal leg length, Distance between Yellow and Blue: preferred step width add 13% personal leg length, Distance between Yellow and Red: preferred step width add 25% individual leg length.

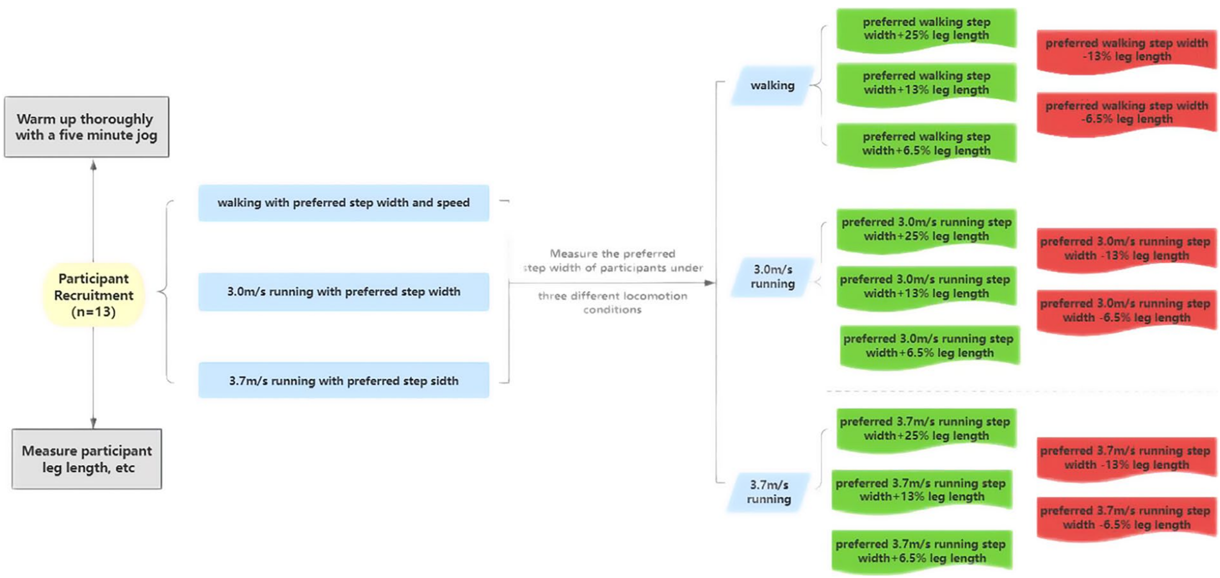

Fig. 3 Outline of the experimental protocols (including Runners Recruitment and Data Collection).

previously recorded for walking, 3.0 m/s running, and 3.7 m/s running were all used to calculate the preferred step width under their respective conditions and averaged to ultimately determine the preferred step width of participants under the three locomotion. The detailed calculation process of preferred step width and the records of each experiment are shown in Fig. 4 and Table 4. Based on calculating the preferred step width, we perturbed the step width by adding (plus) 6.5%, 13%, and 25% and reducing (minus) 6.5% and 13% of the individual participant's leg length as different step width conditions. Previous studies have shown a significant biomechanical difference when the preferred step width is increased or decreased by 13% in leg length, and this study has expanded several step width conditions based on previous studies[5,8,15,23,25]. According to the five different step width conditions, the researchers affixed different colored bands, as shown in Fig. 2, the distance between the yellow band and the dotted line on the force platform indicates the participant's preferred step width.

(6) Different step width trials: Similar to the preferred step width trials, the participants were asked to walk on a straight instrumented path with two force platforms. During the walk, the left foot contacts the yellow band of force platform A, and the right foot contacts the other colored bands of force platform B to represent different color step widths. The instruction was "Blue, to walk as naturally as possible, looking forward." The instructions were randomly assigned to five different colored bands, and the goal was to collect the participants' unconscious natural gait until at least five successful trials of each condition had been

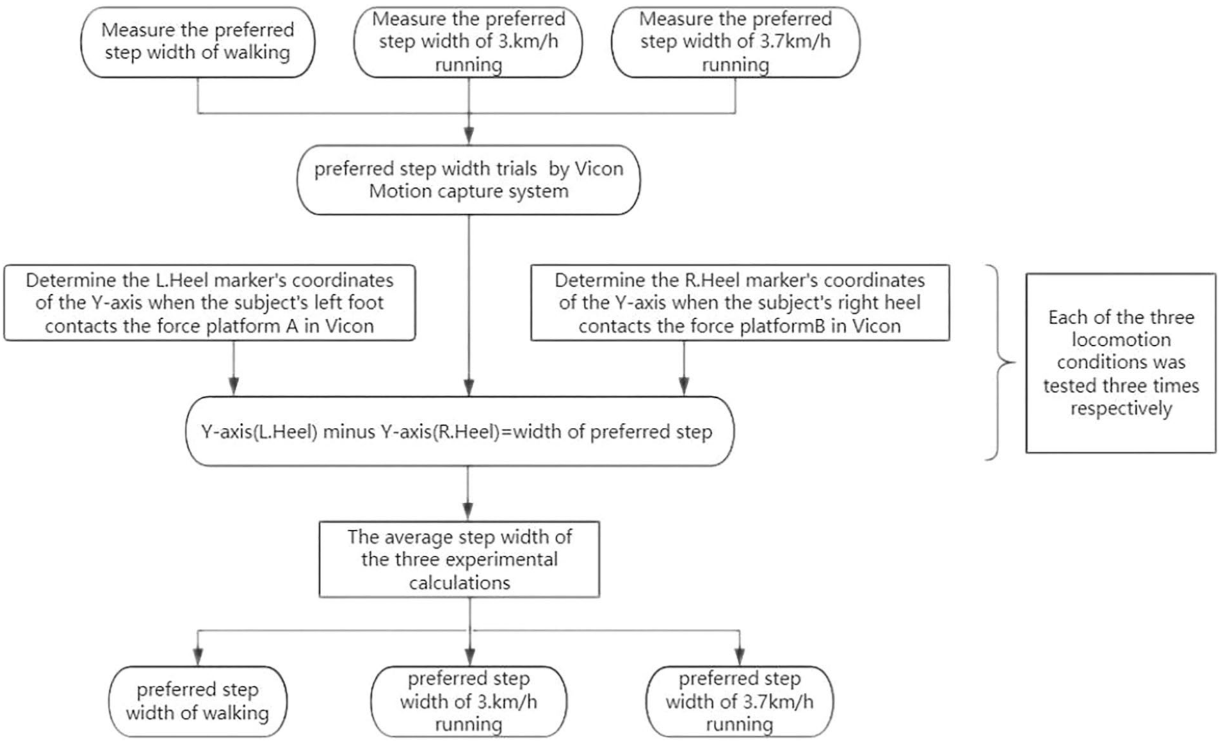

Fig. 4 Detailed calculation process of preferred step width under three locomotion conditions.

	Pw width Trial1	Pw width Trial2	Pw width Trial3	Pw standard deviation	Final Pw width	Pr1 width Trial1	Pr1 width Trial2	Pr1 width Trial3	Pr1 standard deviation	Final Pr1 width	Pr2 width Trial1	Pr2 width Trial2	Pr2 width Trial3	Pr2 standard deviation	Final Pr2 width
P1	127 mm	104 mm	147 mm	22	126 mm	52 mm	60 mm	68 mm	8	60 mm	60 mm	62 mm	70 mm	5	64 mm
P2	73 mm	104 mm	93 mm	16	90 mm	120 mm	110 mm	99 mm	11	109 mm	138 mm	101 mm	97 mm	23	112 mm
P3	188 mm	154 mm	147 mm	22	163 mm	166 mm	181 mm	222 mm	29	190 mm	230 mm	221 mm	187 mm	23	213 mm
P4	161 mm	149 mm	71 mm	49	127 mm	104 mm	127 mm	138 mm	17	123 mm	151 mm	130 mm	82 mm	35	121 mm
P5	123 mm	136 mm	122 mm	8	127 mm	120 mm	98 mm	123 mm	14	114 mm	124 mm	98 mm	123 mm	15	115 mm
P6	93 mm	153 mm	111 mm	31	119 mm	92 mm	130 mm	133 mm	23	118 mm	143 mm	155 mm	122 mm	17	140 mm
P7	118 mm	152 mm	135 mm	17	135 mm	125 mm	152 mm	140 mm	14	139 mm	186 mm	160 mm	156 mm	16	167 mm
P8	158 mm	150 mm	121 mm	19	143 mm	120 mm	139 mm	134 mm	10	131 mm	135 mm	139 mm	155 mm	11	143 mm
P9	201 mm	139 mm	195 mm	34	178 mm	76 mm	82 mm	74 mm	4	77 mm	115 mm	60 mm	67 mm	30	81 mm
P10	203 mm	211 mm	204 mm	4	206 mm	174 mm	127 mm	167 mm	25	156 mm	194 mm	149 mm	191 mm	25	178 mm
P11	170 mm	143 mm	159 mm	13	157 mm	178 mm	189 mm	214 mm	18	194 mm	211 mm	226 mm	209 mm	9	215 mm
P12	159 mm	132 mm	117 mm	21	136 mm	87 mm	114 mm	137 mm	25	113 mm	165 mm	114 mm	113 mm	30	131 mm
P13	150 mm	139 mm	112 mm	20	134 mm	122 mm	153 mm	128 mm	16	134 mm	131 mm	122 mm	157 mm	18	137 mm

Table 4. Information of participants' preferred step width trials. Notes: Pw width (preferred walking step width); Pr1 width (preferred running 1 step width); Pr2 width (preferred running 2 step width).

collected. Then, similarly, successfully collect at least five trials for five-step width conditions at 3.0 m./s and 3.7 m/s running states. The trial's success was defined as (1) the participant walking and running naturally and looking forward during the data collection. (2) The left foot is successfully stepped on the yellow band of force platform A, and the right foot is successfully stepped on the band in the Instruction color of force platform B. (3) The time passed by the electronic timing gates in the running test is within the specified range. (4) The reflective marking points did not fall off during data collection. The researchers rapidly verified all trials. Figure 5 illustrates the participants' locomotion conditions under six-step widths.

Data Process. The collected data were then manually labeled in a Vicon Nexus software (version 1.8.5 A, Vicon Metrics Ltd., Oxford, UK) following the marker-set model as shown in Fig. 1 and Table 3. In terms of the static and dynamic (walking and running) markers trajectories, the gaps were visually checked and manually filled (using "pattern fill" according to the shape of another trajectory without a gap to fill the selected gap) to

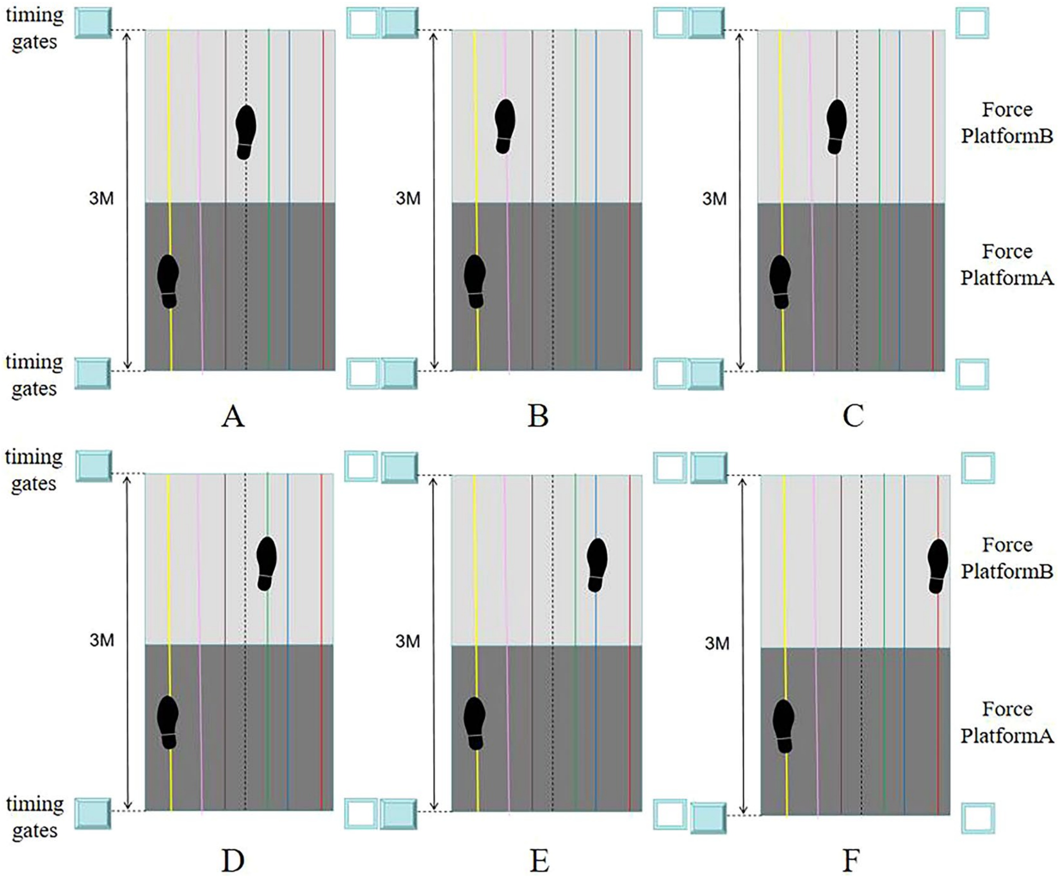

Fig. 5 Participants' locomotion conditions under six step-widths. Notes: (**A**) Running/Walking in preferred step width. (**B**) Running/Walling in preferred step width-13% leg length. (**C**) Running/Walling in preferred step width-6.5% leg length. (**D**) Running/Walling in preferred step width +6.5% leg length. (**E**) Running/Walling in preferred step width +13% leg length. (**F**) Running/Walling in preferred step width +25% leg length. In all conditions, the left foot first contact with Force Platform A, and then the right foot contact with Force Platform B.

avoid inconsistent trajectories[41]. As for the walking and running ground reaction forces, a threshold of 20 N in the vertical direction was employed to detect foot strike and toe-off and define the stance[30]. A pipeline was set in Nexus's workstation to export the raw C3D, MOT, TRC, and CSV files. Consequently, from the experimental tests, each participant received a total of about 55 successful trials, including trials from static, walking, and running at two speeds with six different step-width conditions. The collected data could be applied to compare varying step widths and the comparison of right versus left limb (or dominant versus non-dominant).

One gait cycle (left heel contact to right toe-off) was defined as per the vertical ground reaction force from the force platform during data processing of the trials. The vertical ground reaction force threshold was set at 20 N[30]. The collected experimental data were presented as raw data in C3D files.

Data Records

The dataset is available in the online Figshare repository[41–44]. The recorded markers' trajectory and analog (ground reaction force) data were stored in C3D files, which is a standard file format for biomechanical raw data, with information summarized in Table 5. The C3D.zip folder contains the raw datasets collected from the motion capture experiments. The DOI link of raw ready-for-use data in this study can be found in the following references[41–44].

All data records are available in Table 5. The datasets were organized in four file formats (i.e., C3D, TRC, MOT, CSV) in folders.

Specifically, the TRC files contain marker trajectories in three-dimensional space (X: anterior-posterior, Y: superior-inferior, Z: medial-lateral) with the unit in mm, and data capturing rate at 200 Hz.

The MOT files contain 3-Dimensional Ground Reaction Forces (vx: anterior-posterior, vy: superior-inferior, vz: medial-lateral) with the unit in Newton, and data capturing rate at 1000 Hz. Further, center of pressure trajectories on the force platform was recorded as px (anterior-posterior), py (superior-inferior, as 0 because COP is 2-dimension in x and z directions), and pz (medial-lateral) with unit of mm. The global torque on the force platform was recorded as torque_x (anterior-posterior), torque_y (superior-inferior), and torque_z (medial-lateral) with unit of mm.N.

The CSV files stored the raw force and trajectories without transformation as the TRC and MOT files, which was for other biomechanic software. Specifically, the 3-dimensional Ground Reaction Forces (at 1000 Hz) were expressed as Force (Fx: medial-lateral, Fy: anterior-posterior, Fz: superior-inferior, with unit in Newton),

Trial	Locomotion	speed	step width
pw	walk	preferred walking speed	preferred walking step width
−130w	walk	preferred walking speed	step width at reduced by 13% of leg length
−65w	walk	preferred walking speed	step width at reduced by 6.5% of leg length
65w	walk	preferred walking speed	step width at increased 6.5% of leg length
130w	walk	preferred walking speed	step width at increased 13% of leg length
250w	walk	preferred walking speed	Step width at increased 25% of leg length
pr1	run	3.0 m/s	preferred 3.0 m/s running step width
−130r1	run	3.0 m/s	Step width at reduced 13% of leg length
−65r1	run	3.0 m/s	Step width at reduced 6.5% of leg length
65r1	run	3.0 m/s	Step width at increased 6.5% of leg length
130r1	run	3.0 m/s	Step width at increased 13% of leg length
250r1	run	3.0 m/s	Step width at increased 25% of leg length
pr2	run	3.7 m/s	preferred 3.7 m/s running step width
−130r2	run	3.7 m/s	Step width at reduced 13% of leg length
−65r2	run	3.7 m/s	Step width at reduced 6.5% of leg length
65r2	run	3.7 m/s	Step width at increased 6.5% of leg length
130r2	run	3.7 m/s	Step width at increased 13% of leg length
250r2	run	3.7 m/s	Step width at increased 25% of leg length

Table 5. Data Records.

Moment (Mx: medial-lateral, My: anterior-posterior, Mz: superior-inferior, with unit in mm.N) and CoP (Cx: medial-lateral, Cy: anterior-posterior, Cz: zero due to the 2D feature of COP, with unit in mm). The marker trajectories (at 200 Hz) were expressed in three-dimensions as X in medial-lateral direction, Y in anterior-posterior direction, and Z in superior-inferior direction (with unit in mm).

Each file format folder has 13 subfolders that represent 13 participants, and trial files in 13 subfolders are referenced in our datasets as Pxx_CV_TT.C3D (TRC/MOT/CSV) and static files as Pxx_Cal_TT. C3D (TRC/MOT/CSV),

- Pxx: identification of the participant number
- C: step width conditions, i.e., −130, −65, p, 65, 130, or 250
- V: locomotion condition, i.e. w, r1, or r2
- TT: trial number, i.e. 01 to 10
- Cal: static

Technical Validation

The motion capture system and lab setting were calibrated before each experimental session to avoid noise and ensure high marker visibility. In terms of the marker gaps, a manual gap filling was performed using "pattern fill" according to the shape of another trajectory without a gap to fill the selected gap, and the force plate was checked (and zero-level) before each session to ensure an accurate measurement of ground reaction forces. Similar procedures were followed by the recently published data descriptor studies[31–34,45].

All the walking and running marker trajectories and ground reaction forces stored in the raw C3D files were visually inspected and checked in the Motion Kinematics & Kinetics Analyzer (MOKKA) BTK software. The coordinate system of lab-collected (Vicon) datasets (C3D files) was then transformed to match the OpenSim global and local coordinate systems, resulting in positive $\boldsymbol{X}$ to the anterior, positive $\boldsymbol{Y}$ to the superior, and positive $\boldsymbol{Z}$ to the right for post-data processing of OpenSim users.

The following pipelines were conducted in OpenSim v4.0 according to the previously established data processing workflow, including the '*Scale*', '*Inverse Kinematics*', and '*Inverse Dynamics*'[46]. Figures 6–14 show the hip kinematics under different step width conditions at running and walking. The processed (ready-for-use) kinematics results shown in Figs. 15 to 17 were compared against recent studies of walking and confirmed with similar shape trends and magnitude from the authors. By calculating the Intra-class Correlation Coefficient (ICC) of hip ROM (range of motion), this dataset is highly correlated with those in previously published papers[46]; the ICC for hip flexion is 0.994 (95CI% = 0.989–0.996); the ICC for hip adduction is 0.923 (95CI% = 0.867–0.995); and the ICC for hip rotation was 0.680 (95CI% = 0.456–0.613).

Usage Notes

During data collection, we strictly followed the experimental procedures and had professional researchers monitoring the experimental method, to ensure that each participant successfully took five sets of experimental data under the different speed conditions of walking and running. However, we found that a few participants failed to achieve five sets of successful data under individual experimental conditions during the data processing post the

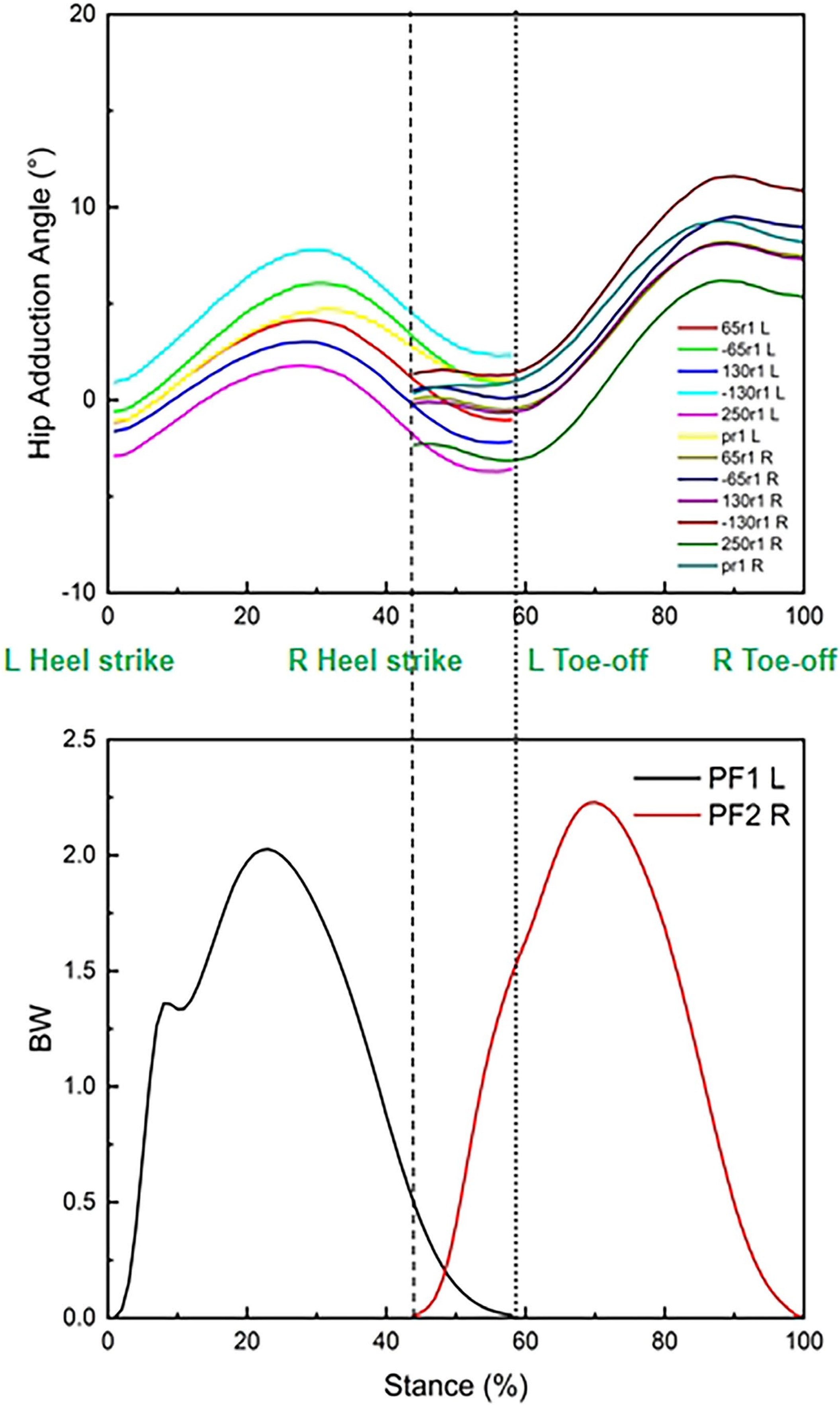

Fig. 6 Hip kinematics in three planes under different step widths at running and walking.

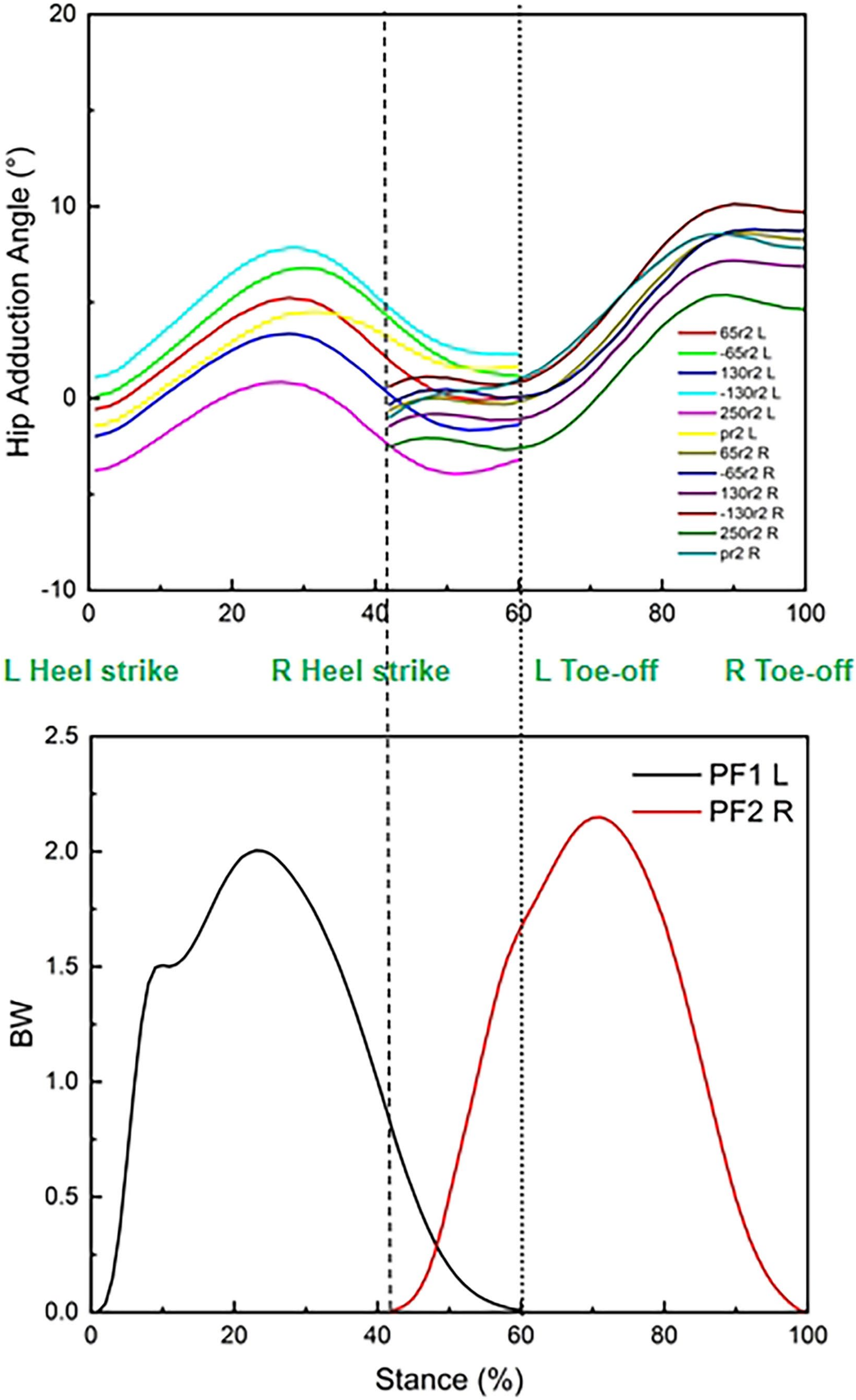

Fig. 7 Hip kinematics in three planes under different step widths at running and walking.

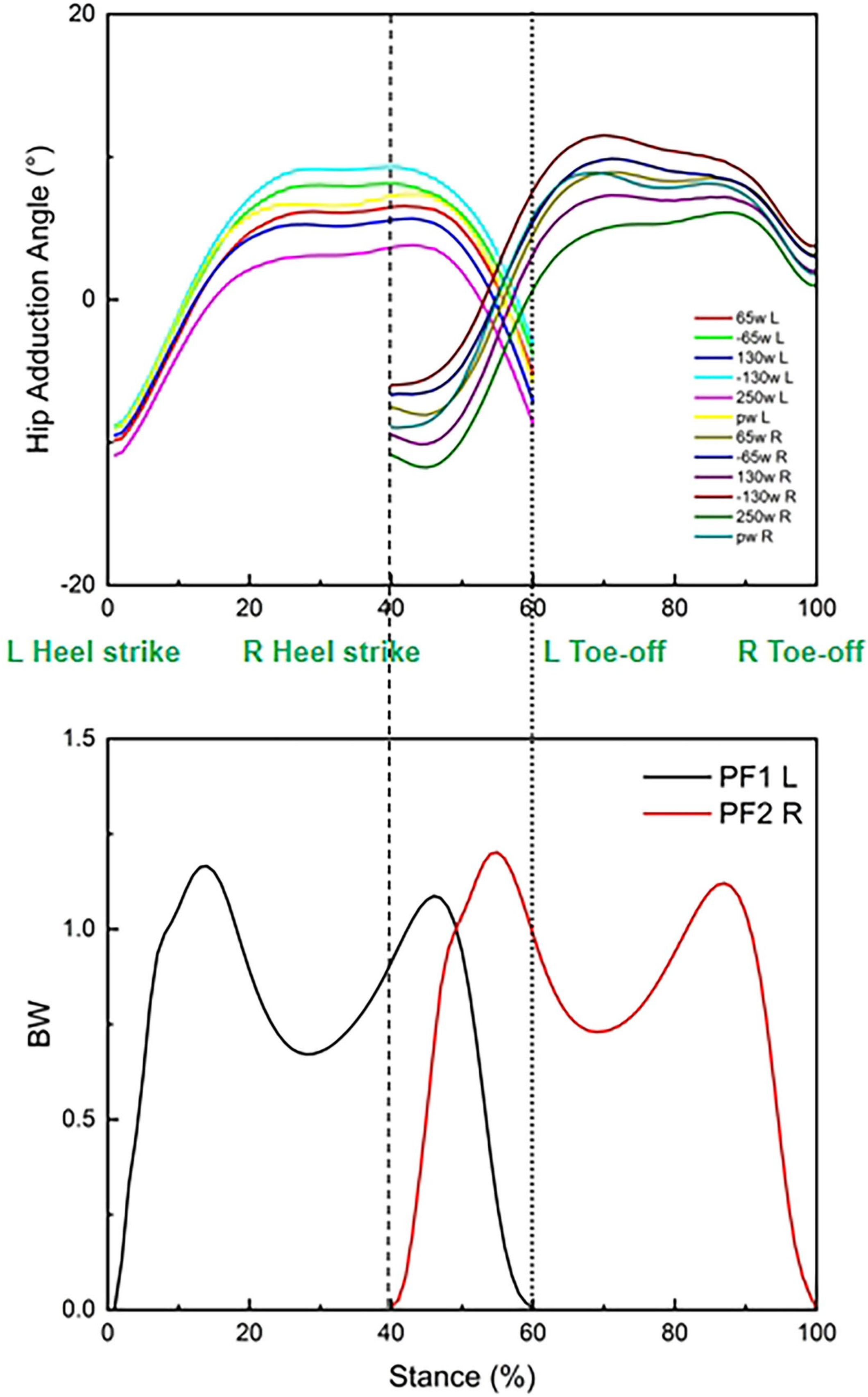

Fig. 8 Hip kinematics in three planes under different step widths at running and walking.

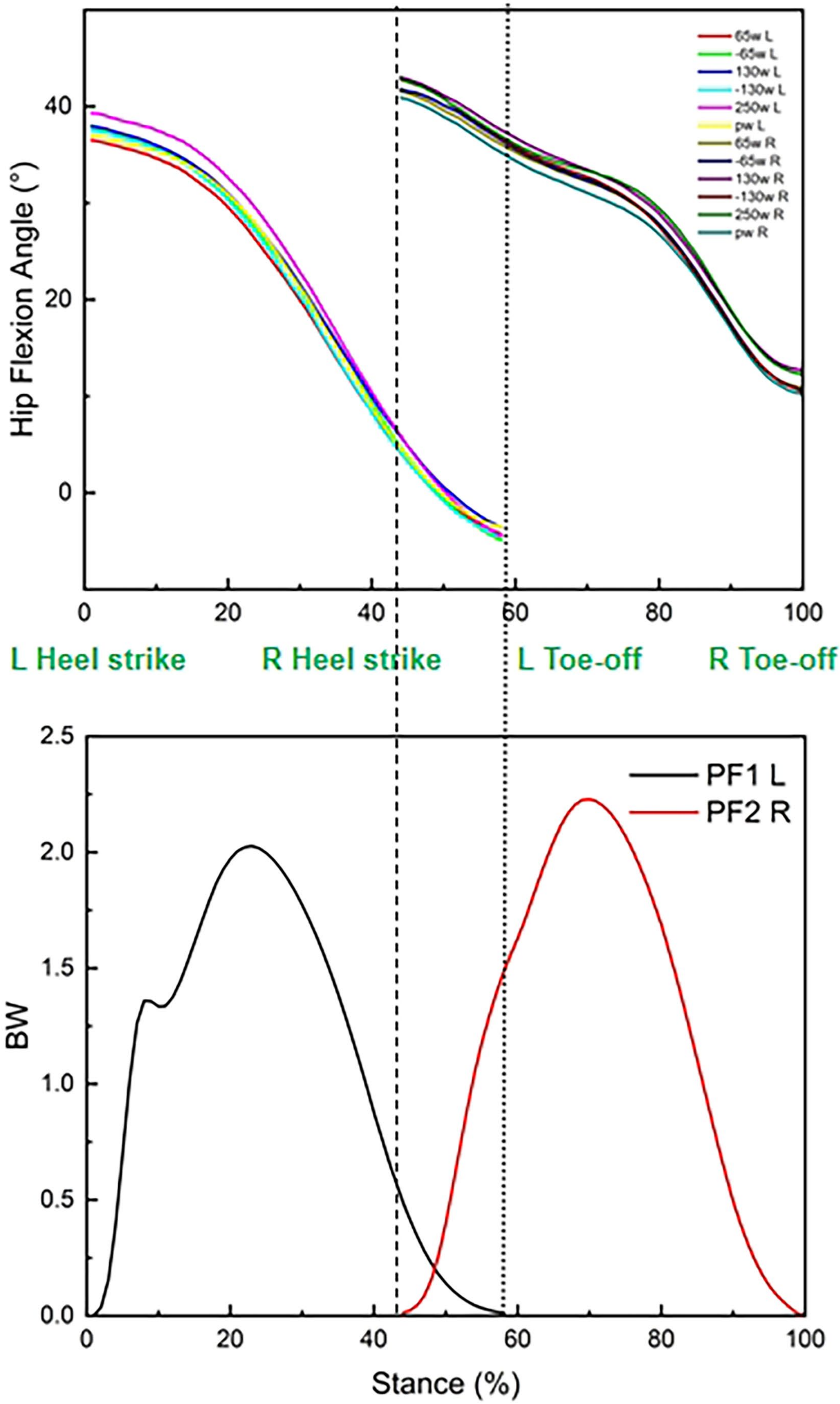

Fig. 9 Hip kinematics in three planes under different step widths at running and walking.

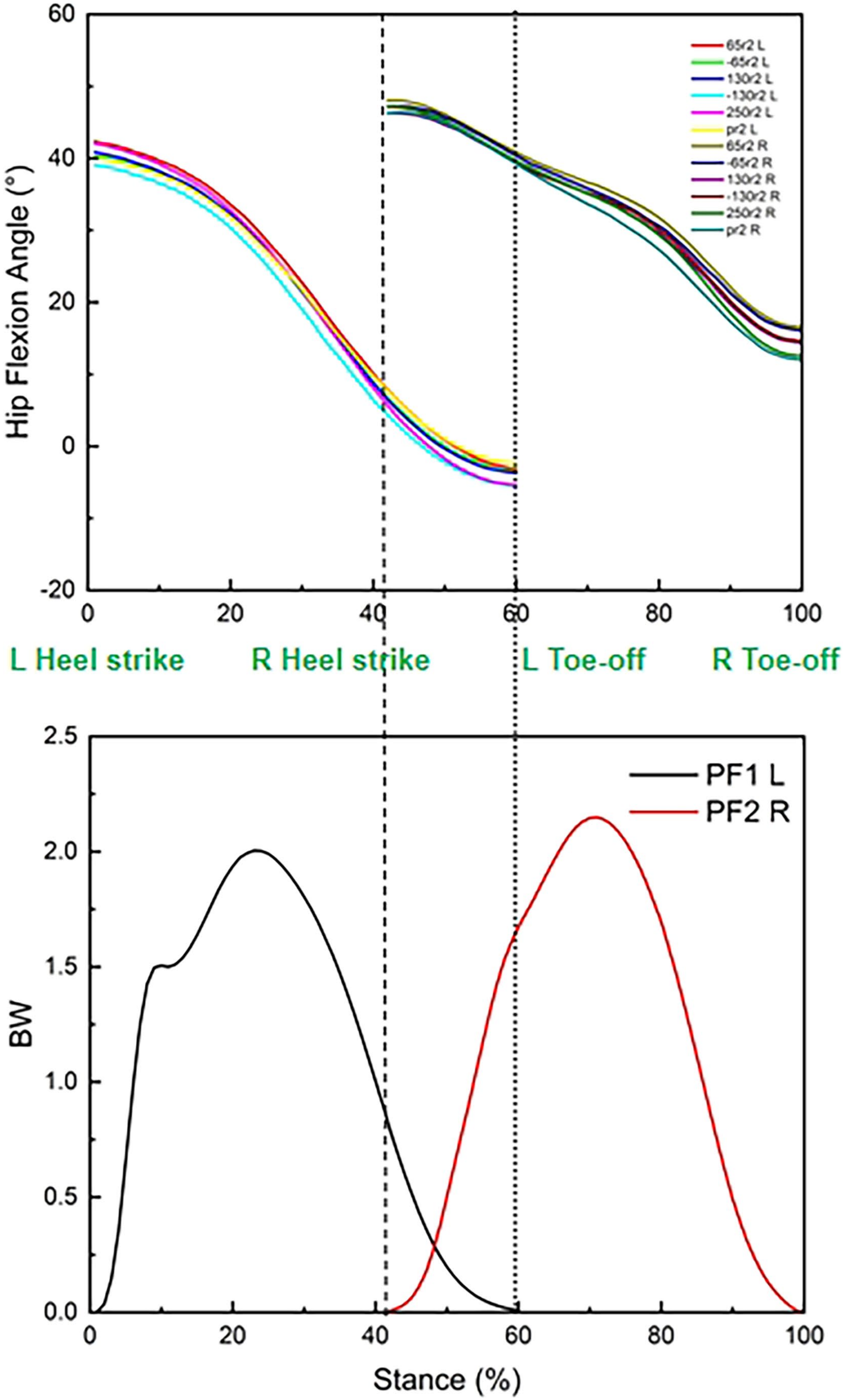

Fig. 10 Hip kinematics in three planes under different step widths at running and walking.

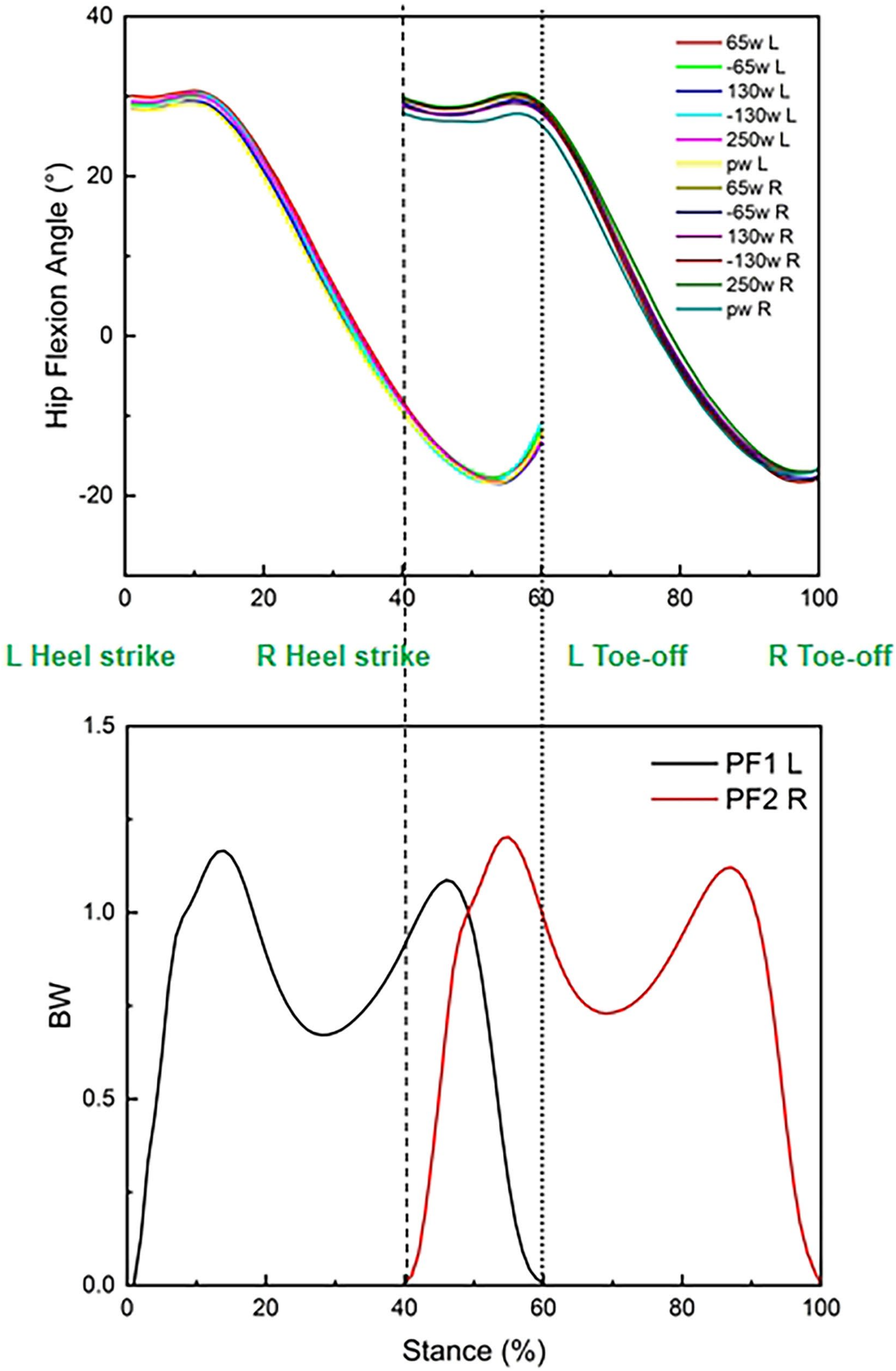

Fig. 11 Hip kinematics in three planes under different step widths at running and walking.

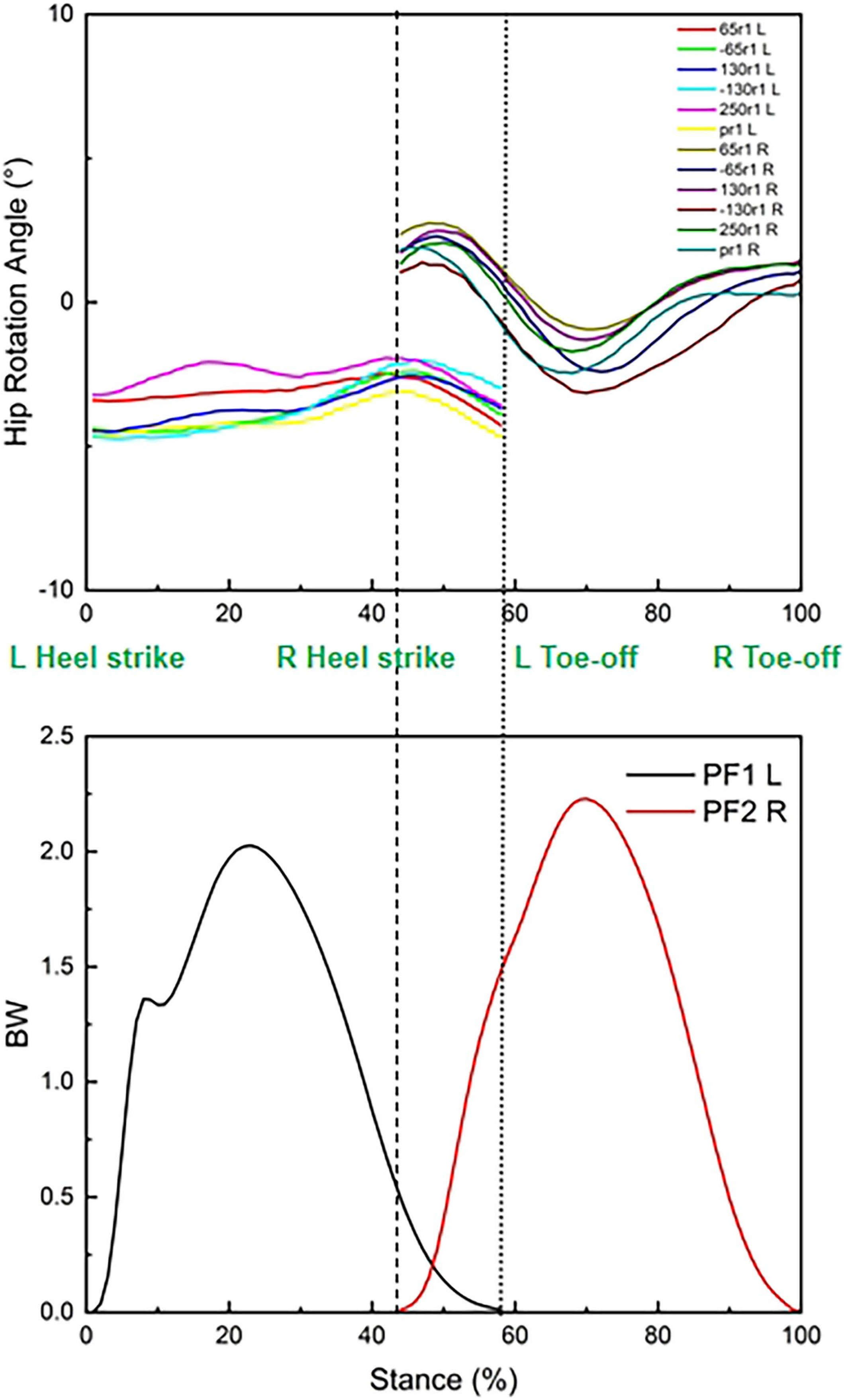

Fig. 12 Hip kinematics in three planes under different step widths at running and walking.

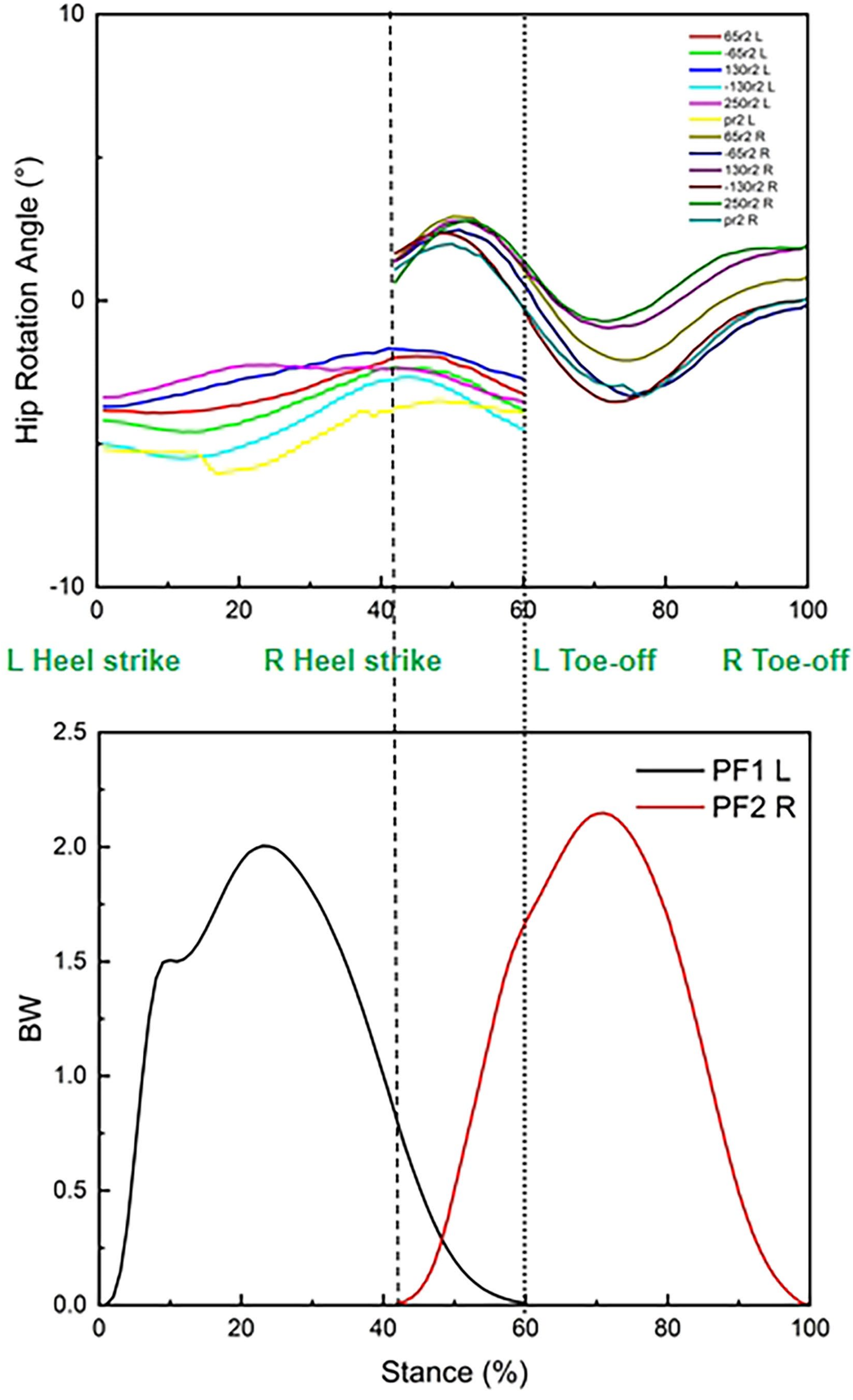

Fig. 13 Hip kinematics in three planes under different step widths at running and walking.

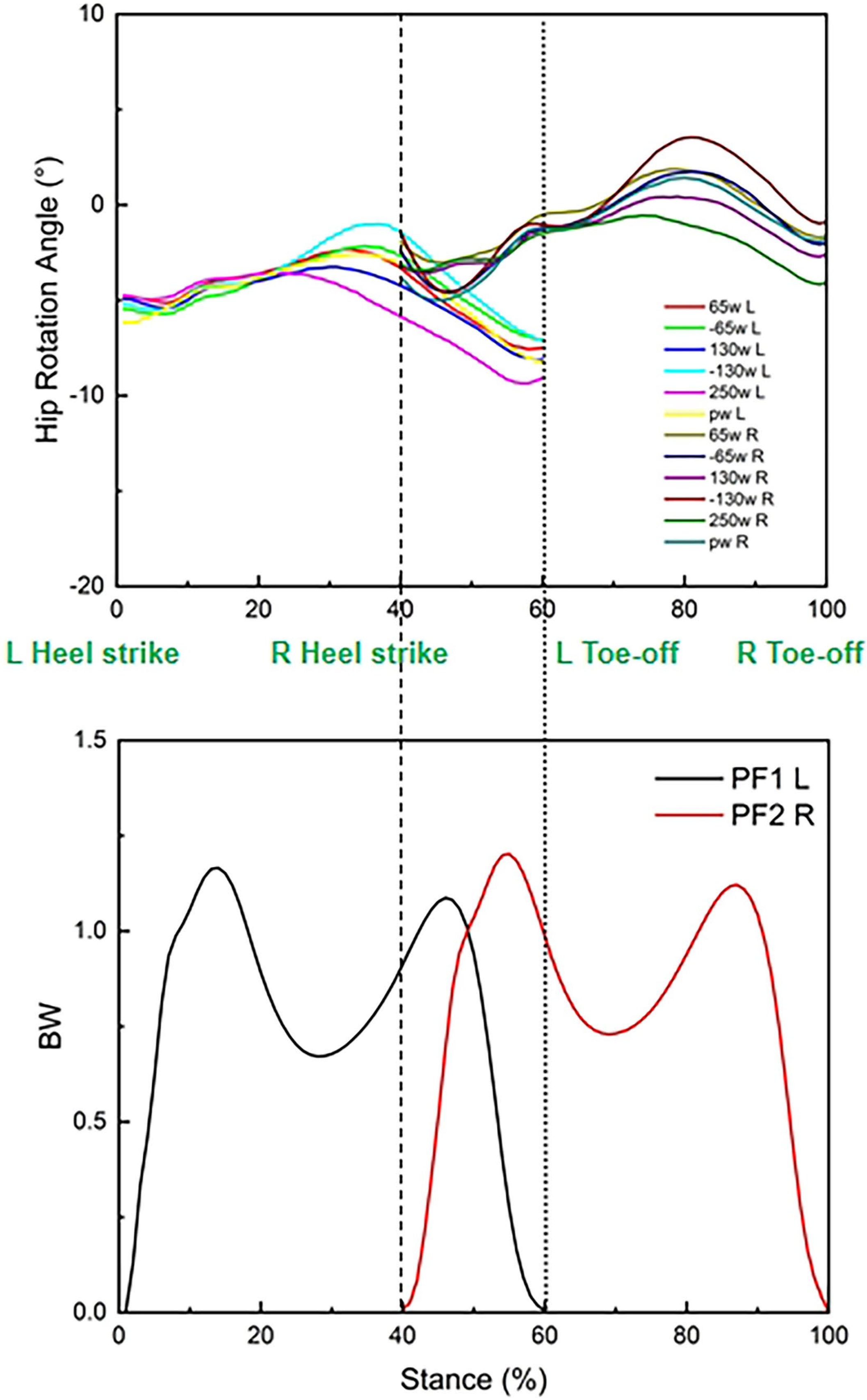

Fig. 14 Hip kinematics in three planes under different step widths at running and walking.

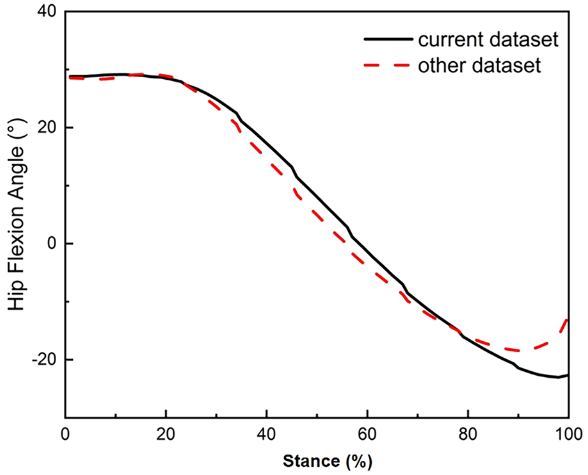

Fig. 15 Comparison of hip kinematics from the present dataset literature during walking at preferred speed and step width.

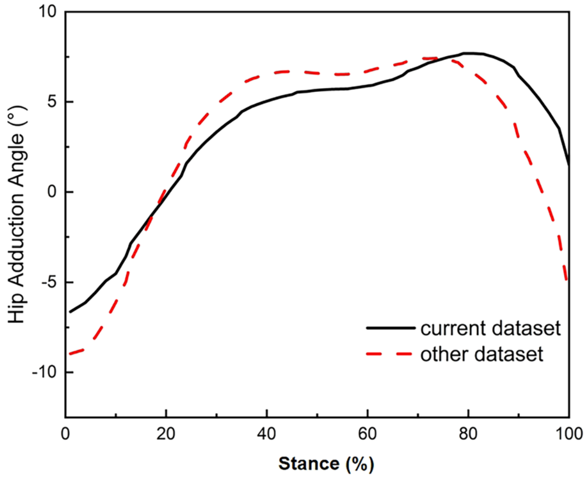

Fig. 16 Comparison of hip kinematics from the present dataset literature during walking at preferred speed and step width.

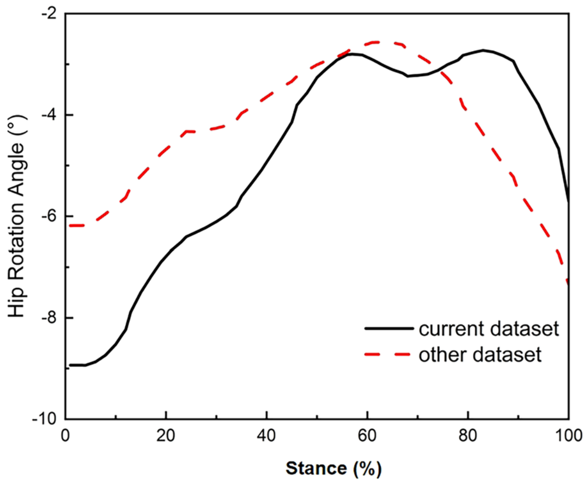

Fig. 17 Comparison of hip kinematics from the present dataset literature during walking at preferred speed and step width.

experiment. Thus, we presented a minimum of 2-3 data trials of data for each participant under different speed or step width walking and running conditions.

A limitation, that shall be considered in this dataset, is that during data acquisition, participants' running speed was recorded by single beam electronic timing gates rather than on a treadmill at a stable speed, which could lead to variations in the participants' speed as passing through the force platforms. Secondly, this study presented the datasets of the physically active males of Chinese ethnicity. While considering the population-based running biomechanical performance and related injuries, this database of 13 participants (relatively small sample size) may be a foundation and provide a pilot example for future studies to expand the samples of runners from different ethnicities.

Code availability

All the C3D and TRC files could be visualised using the MOKKA BTK, available in the online repository (http://biomechanical-toolkit.github.io).

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Author contributions

Y.W., Q.M. and H.J.: Conceptualization, Methodology, Writing – Original Draft; Y.W., H.J., X.Y. and B.L.: Software, Formal Analysis, Visualization; Q.M., B.L., J.F. and Y.G.: Validation, Investigation, Writing – Review & Editing; Q.M., J.F. and Y.G.: Supervision, Project Administration, Funding Acquisition.

Competing interests

The authors declare no competing interests.

Additional information

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