EU – FP7

AMARSi

Adaptive Modular Architectures for Rich Motor Skills

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First data basis with scenario-specific motion capture data

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First data basis with scenario-specific motion capture data

The general objective of WP1 is to inform the development of a biologically-grounded adaptive modular architecture for robots with existing and new knowledge on the human motor control and cognitive architecture. With this deliverable the partners involved in human motor control research provide to the consortium a first motion capture data basis of human motor skills to be used for benchmarking and for the evaluation of the experimental scenarios (WP7).

Some of the data provided have been collected during the performance of human motor tasks closely related to the robotic experimental scenario E1 (partial skills), such as basic crawling, locomotion, reaching. Other data have been collected during the performance of more complex motor skills either involving complex sensorimotor transformations, such as drawing and catching, or involving combinations of skills (as in scenario E2.1). Most of the data have been collected in the context of the experiments being conducted to extend the investigation of motor primitives to rich motor skills (T.1.3). Data have been collected both in infants and adults.

Most motion capture data have been recorded with the same optical motion capture system (Vicon, Vicon Motion Systems, Oxford, UK; used by SLF, UniBi, and UniTu) using passive markers attached to the subject's body. Other data have been collected with electromagnetic tracking systems (Fastrak and Liberty, Colchester, VT, USA; SLF and Weizmann) or simpler motion capture systems (digitizing tablet, reconstruction from video) adequate for the specific task being investigated. All VICON data are stored in a standard file format (C3D) while data captured with other systems are stored using Matlab data structures or XML files.

In the following sections of this documents each motion capture data sets made available by the partners is described in a summary table. The table includes a description of the motor task and of the experimental conditions, a description of the motion capture system used and the anatomical positions of the recorded markers, whether additional data (such as EMGs) have also been collected, and the data storage format.

Samples motion capture data are available to the consortium on the AMARSi Collaboration Environment (in compressed file archives including a brief description of the data) (https://redmine.amarsi-project.eu/projects/data/documents).

Infant locomotion

1.1 Crawling

Partner	SLF	
Task	Description	Free crawling on a track (5 m x 1.5 m) to reach for a toy handled by the experimenter on the opposite side
	Subjects	5 infants (age range: 9 to 11 months)
Data	Motion capture system	Vicon-612 (9 cameras, Vicon Motion Systems, Oxford, UK. Capture frequency: 100 Hz.
	Marker positions 	lower limb, bilateral (R: right, L: left): • the tubercle of the anterosuperior iliac crest (IL) • greater trochanter (GT) • lateral femur epicondyle (LE) • lateral malleolus (LM) • fifth metatarso-phalangeal joint (VM) upper limb, bilateral: • gleno-humeral joint (GH) • elbow (ELB) • wrist (WRI)
	Additional data	Leg, trunk, arm, EMGs (up to 20 channels, recorded with 2 16-channel Trigno wireless systems sampled at 2 KHz, Delsys Inc., Boston, USA).
Data storage format	Data file types	Vicon C3D (.c3d) and ASCII file (.txt) for EMGs (onset synchronized).

Sample data are available in the Datasets project of the AMARSi Collaboration Environment (https://redmine.amarsi-project.eu/documents/49).

1.2 Neonatal stepping

Partner	SLF	
Task	Description	Stepping reflex elicited by holding the infant under their arms with their feet touching an horizontal flat walkway surface
	Subjects	neonates (age range: 2 to 7 days)
Data	Motion capture system	Sagittal plane projection of makers reconstructed from videotape (25 Hz) using an interactive software
	Marker positions 	lower limb (sagittal plane projection), unilateral: • greater trochanter (GT) • lateral femur epicondyle (LE) • lateral malleolus (LM) • fifth metatarso-phalangeal joint (VM)
	Additional data	Foot pressure measurements (Tekscan walkway, Tekscan Inc., Boston, USA; 50 Hz), EMGs (up to 22 channels, Zerowire wireless system, Aurion, Milan, Italy; 2KHz).
Data storage format	Data file types	Matlab (.mat) structures.

Sample data are available in the Datasets project of the AMARSi Collaboration Environment (https://redmine.amarsi-project.eu/documents/55).

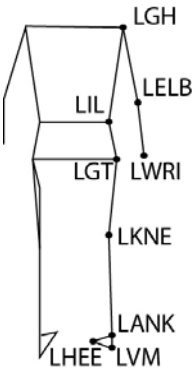
Toddler stepping

Partner	SLF	
Task	Description	Unsupported steps (within two weeks of onset of independent walking) on a track (5 m x 1.5 m) to reach for a toy handled by the experimenter on the opposite side
	Subjects	5 infants (age range: 9 to 11 months)
Data	Motion capture system	Vicon-612 (9 cameras), Vicon Motion Systems, Oxford, UK. Capture frequency: 100 Hz.
	Marker positions 	lower limb, bilateral (R: right, L: left): • the tubercle of the anterosuperior iliac crest (IL) • greater trochanter (GT) • lateral femur epicondyle (LE or KNE) • lateral malleolus (LM or ANK) • fifth metatarso-phalangeal joint (VM) • heel (HEE) upper limb, bilateral: • gleno-humeral joint (GH or SHO) • elbow (ELB) • wrist (WRI)
	Additional data	Leg, trunk, arm, EMGs (up to 20 channels, recorded with 2 16-channel Trigno wireless systems sampled at 2 KHz, Delsys Inc., Boston, USA).
Data storage format	Data file types	Vicon C3D (.c3d) and ASCII file (.txt) for EMGs (onset synchronized).

Sample data are available in the Datasets project of the AMARSi Collaboration Environment (https://redmine.amarsi-project.eu/documents/50).

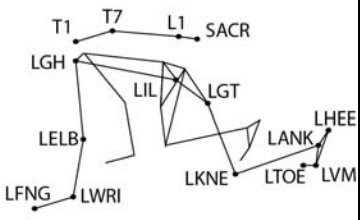
2 Adult locomotion

2.1 Walking and running on treadmill

Partner	SLF	
Task	Description	Subjects are instructed to walk or run on a treadmill.
	Conditions	1. Walking. Treadmill speeds: 3, 5, 7 Km/h 2. Running. Treadmill speeds: 7, 9 Km/h
	Subjects	8 adults
Data	Motion capture system	Vicon-612 (9 cameras) , Vicon Motion Systems, Oxford, UK. Capture frequency: 100 Hz.
	Marker positions 	lower limb, bilateral (R: right, L: left): • the tubercle of the anterosuperior iliac crest (IL) • greater trochanter (GT) • lateral femur epicondyle (LE or KNE) • lateral malleolus (LM or ANK) • fifth metatarso-phalangeal joint (VM) • heel (HEE) upper limb, bilateral: • gleno-humeral joint (GH or SHO) • elbow (ELB) • wrist (WRI)
	Additional data	Leg, trunk, arm, EMGs (up to 32 channels, systems, Delsys Inc., Boston, USA, 1 KHz, or Zerowire wireless system, Aurion, Milan, Italy, 2 KHz).
Data storage format	Data file type	Vicon C3D (.c3d) (including analog data for EMGs)

Sample data are available in the Datasets project of the AMARSi Collaboration Environment (walking: https://redmine.amarsi-project.eu/documents/51; running: https://redmine.amarsi-project.eu/documents/52).

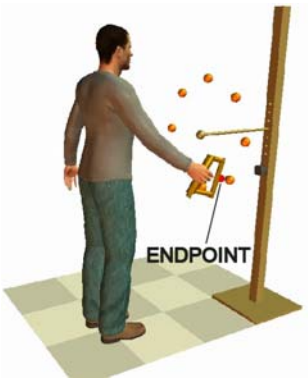
2.2 Crawling

Partner	SLF	
Task	Description	Subjects are instructed to crawl on a treadmill.
	Conditions	Treadmill speeds: 0.5, 1, 1.5, 2, 2.5, 3 Km/h
	Subjects	10 adults
Data	Motion capture system	Vicon-612 (9 cameras), Oxford, UK. Capture frequency: 100 Hz.
	Marker positions	 trunk: • thoracic vertebrae (T1, T7) • lumbar vertebra (L1) • sacral bone (SACR) lower limb, bilateral (R: right, L: left): • the tubercle of the anterosuperior iliac crest (IL) • greater trochanter (GT) • lateral femur epicondyle (LE or KNE) • lateral malleolus (LM or ANK) • fifth metatarso-phalangeal joint (VM) • heel (HEE) • distal phalange of the toe (TOE) upper limb, bilateral: • gleno-humeral joint (GH or SHO) • elbow (ELB) • wrist (WRI) • distal phalange of the middle finger (FNG)
	Additional data	Leg, trunk, arm, EMGs (up to 31 channels, recorded with Trigno wireless systems sampled at 2 KHz, Delsys Inc., Boston, USA).
Data storage format	Data file type	Vicon C3D (.c3d) (including analog data for EMGs)

Sample data are available in the Datasets project of the AMARSi Collaboration Environment (https://redmine.amarsi-project.eu/documents/53).

3 Adult upper limb movements

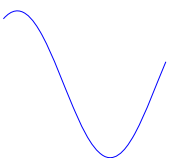
3.1 Reaching

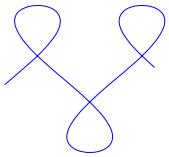
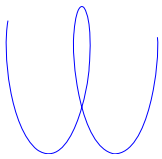
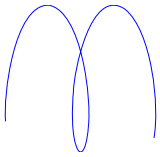
Partner	SLF	
Task	Description	Standing subjects are instructed to move a marker on a handle they grip between a central target (0) and 8 peripheral targets (1-8) on a vertical plane (frontal and sagittal).
	Conditions	1. center-out (0->i) and out-center (i->0) point-to-point movements with 3 different handle masses (180 g, 630 g, 1040 g) 2. point-to-point, reversal (0->i->0; i->0->i), and via-point (i->0->j). 3. point-to-point, tangential (i->i+1; i->i-1) and jump of target (1-8) to one of the two adjacent locations (i+1; i-1) after one of three delay (50, 150, 250 ms) after the go signal.
	Subjects	11 right handed subjects (3 for cond.1; 3 for cond. 2; 5 for cond. 3; age range: 23 – 40 yr)
Data	Motion capture system	Fastrak, Polhemus, Colchester, VT, USA. Capture frequency: 120 Hz.
	Marker position 	Arm endpoint (reference sphere on the handle aligned with forearm axis)
	Additional data	Shoulder and elbow EMGs (from up to 19 muscles, recorded at 1 KhZ with Bagnoli-16 system, Delsys Inc., Boston, USA).
Data storage format	Data file type	Matlab (.mat) structures.

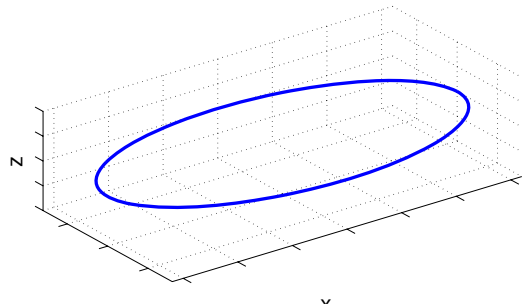
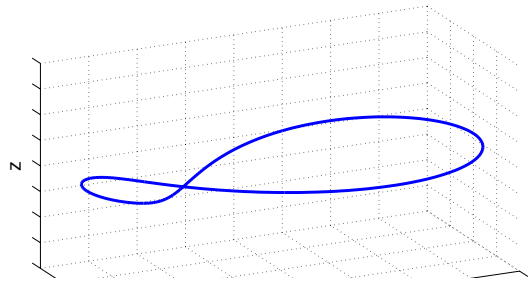
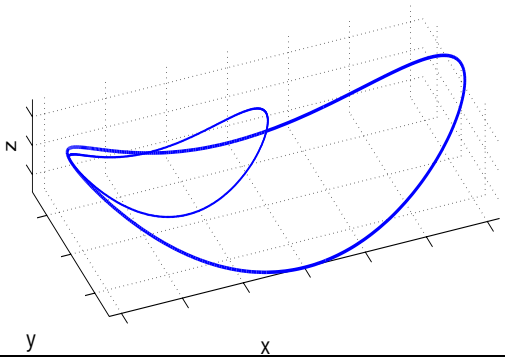
Sample data are available in the Datasets project of the AMARSi Collaboration Environment (https://redmine.amarsi-project.eu/documents/48).

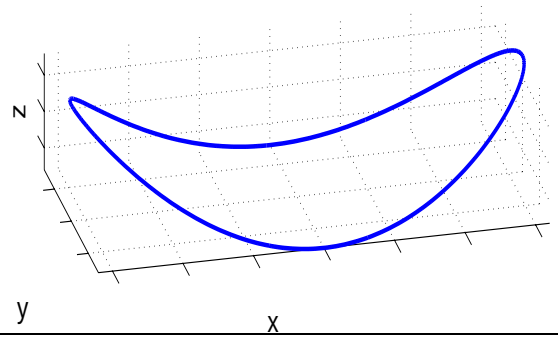
Partner	Weizmann	
Task	Description	The subjects were asked to do point to point reaching in a comfortable pace with their dominant arm in three-dimensional (3D) space.
	Conditions	The subject were presented a target in front of them were in each trial the target was moved to a different location.
	Subjects	5 adult subjects
Data	Motion capture system	Liberty, Polhemus, Colchester, VT, USA; 240Hz.
	Marker positions	Wrist, forearm, upper arm, shoulder and chest around the collarbone next to the arm (8 channels) .
	Additional data	The angles at the elbow and shoulder joints (in both relative and absolute frames) were computed from the sensors data.
Data storage format	Data file type	Matlab (.mat)

3.2 Drawing

Partner	Weizmann	
Task	Description	The subjects were asked to draw the given shapes on a table. The shape was not posted on the tablet for the subject to follow. Instead, the shape was presented to them with marking of via-points at the local maxima and minima of the Y-axis. The same via-point, without the shape where located on the tablet as guidelines for the subject how to draw the shape.
	Conditions	The experiment contains 4 shapes: Sinus, Winding, Coil opened and closed. Every subject participates in two sessions with 15 minute of rest between the sessions. In each trial the subject was asked to draw a set of eight repetitions of one of the shapes. Four trials for each shape was performed in each session. In two of the trials the subjects drew the shape from right to left and in the other two trials the subjects drew the shape from left to right. The order of the shapes was chosen randomly for each subject and each shape.
	Subjects	10 Adults
Data	Motion capture system	Position of a stylus on a 2D Tablet: Wacom; Model GD-1218-R, 200 Hz
	Shapes	The shapes were chosen so that they will fulfil few guidelines. First, the subject will be able to draw the shapes using only via points as guidance without the need for a template to be placed on the digitizing tablet. Second, the shapes will not be periodic but still can be drawn repeatedly one after the other. In addition we selected shapes that include singularities. The Coil opened, Coil closed and Sinus shapes are natural and easy to draw. The Winding shape, on the other hand, is harder to draw correctly and subjects needed to practice it 3 or 4 times before drawing it properly.
		Sinus: 

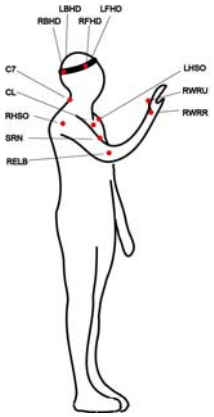
		Winding: 
		Coil opened 
		Coil Closed: 
Data storage format	Data file type	Matlab (.mat) structures

Partner	Weizmann	
Task	Description	The subjects were instructed to freely draw a series of shapes repetitively in a comfortable pace with their dominant arm in three-dimensional (3D) space.
	Conditions	Ten paths were used: planar ellipse (PE), vertical ellipse drawn on the sagittal plane (PE-V), ellipse drawn on the frontal plane (PE-F), planar ellipse drawn on a plane rotated 45 off the sagittal plane (PE-45V), ellipse drawn on a plane rotated 45 off the frontal plane (PE-45F), horizontal figure-eight (FE), vertical figure-eight drawn on the sagittal plane (FE-V), figure-eight drawn on the frontal pla (DI of t
	Shapes	Elli  Fig  Dou 

		B 
	Subjects	5 adult subjects
Data	Motion capture system	Polhemus Liberty, 240Hz
	Marker positions	Wrist, forearm, upper arm, shoulder and chest around the collarbone next to the arm (8 channels)
	Additional data	
Data storage format	Data file type	Matlab (.mat)

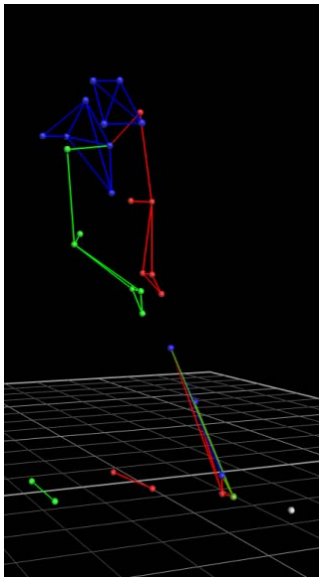
3.3 Catching

Partner	SLF	
Task	Description	Standing subjects are instructed to catch a ball (diameter 7 cm, mass 20 g) projected from an exit hole in a screen at a distance of 6 m with different ball flight parameters.
	Conditions	Three flight durations (T, from exit hole to the vertical plane at distance 6 m): 550, 650, 750 ms; two interception heights (Z, below and above shoulder height).
	Subjects	6 adults (age range: 22 – 42 yr, right handed)
Data	Motion capture system	Vicon-612 (9 cameras), Oxford, UK. Capture frequency: 100 Hz.
	Marker positions	Head, bilateral (left: L, right: R): • front (FHD) • back (BHD) Trunk: • cervical vertebrae (C7) • sternum, caudal extremity (SRN) • sternum, rostral extremity, between clavicles (CL) Upper limb, bilateral (left: L, right: R): • acromion (SHO); Upper limb unilateral (right): • elbow, epicondiylos lateralis (ELB) • wrist, extremities of a stick (length 21 cm) attached along the axis between ulnar styloid and radial styloid (WRU, WRR) Setup: • Ball (covered by retroreflective tape, BALL) • Three markers on launch plane (PLANE1, PLANE2, PLANE3)
	Additional data	Leg, trunk, arm, EMGs (up to 21 channels, recorded at 1 KhZ with 2 Bagnoli-16 systems, Delsys Inc., Boston, USA).
Data storage format	Data file type	Vicon C3D (.c3d) (including analog data for EMGs)



Sample data are available in the Datasets project of the AMARSi Collaboration Environment (https://redmine.amarsi-project.eu/documents/54).

3.4 Golf Putting

Partner	UniBi	
Task	Description	Golf putt performed by skilled and novice golfers. Distance of the golf putt was 1.5m.
	Conditions	Participants performed the golf putt with both hands, left hand only, and right hand only.
	Subjects	Adults
Data	Motion capture system	Vicon (12 cameras), Oxford, UK. Capture frequency: 200 Hz.
	Marker positions 	Upper Body: • Left front head (LFHD) • Right front head (RFHD) • Left back head (LBHD) • Right back head (RBHD) • 7th Cervical Vertebrae (C7) • 10th Thoracic Vertebrae (T10) • Clavicle (CLAV) • Sternum (STRN) • Right back shoulder blade (RBAK) Upper limb, bilateral: • Shoulder marker (SHO) • Elbow (ELB) • Medial/Inner elbow (ELBM) • Wrist marker thumb side (WRA) • Wrist marker pinkie side (WRB) • Finger (FIN) Lower Body, bilateral: • Toe (TOE) • Heel (HEE)
	Additional data	Bicep and forearm (extensors and flexors) EMG (6 channels recorded with Myon system, Myon AG, Baar, Switzerland), Eye-tracking (SMI iViewX HED mobile Eyetracking System: 200 Hz, monocular): textfile with the event data plus video (.avi, Xvid Codec). Cognitive representation data was also recorded (SDA-M).
Data storage format	Data file type	Vicon C3D (.c3d) (including analog data for EMGs.

Sample data are available in the Datasets project of the AMARSi Collaboration Environment (https://redmine.amarsi-project.eu/documents/62).

3.5 Grasping

Partner	UniBi	
Task	Description	Grasping known and unknown objects
	Conditions	Two stage experiment: First stage: Participants grasped 8 known and 8 unknown objects (10 seconds). Second stage: Participants performed typical movements with the objects (20 seconds).
	Subjects	Adults
Data	Hand posture capture system	Immersion CyberGlove wireless data glove, 90 Hz, 22 DoF.
	Sensor positions 	22 sensors altogether: • 18 flexion sensors • 4 abduction sensors (between fingers)
	Additional data	Eye-tracking (SMI iViewX HED mobile Eyetracking System: 200 Hz, monocular): textfile with the event data plus video (.avi, Xvid Codec). Cognitive representation data was also recorded (SDA-M).
Data storage format	Data file type	XML file (containing raw sensors values)

3.6 Pointing in Virtual Reality

Partner	UniBi	
Task	Description	Adult participants were required to reach and point to floating boxes in a virtual reality environment
	Subjects	Adults
Data	Motion capture system	Vicon (12 cameras), Oxford, UK. Capture frequency: 200 Hz.
	Marker positions 	Upper Body: • Left front head (O) • Right front head (P) • Left back head (S) • Right back head (A) • 7th Cervical Vertebrae (C7) • 8th Thoracic Vertebrae (T8) • Clavicle (IJ) • Sternum (PX) • Scapula inferior (SCI) • Scapula superior (SCS) • Right shoulder (RSHO) • Asymmetric right upper arm (ARUPARM) • Right lateral elbow (RELL) • Right medial elbow (RELM) • Asymmetric right lower arm (ARLOARM) • Right lateral wrist (RWRL) • Right medial wrist (RWRM) • Right metacarpal phalanx (RMCP) • Index finger (I) • Thumb (T)
Data storage format	Data file type	Vicon C3D (.c3d)

Sample data are available in the Datasets project of the AMARSi Collaboration Environment (https://redmine.amarsi-project.eu/documents/64).

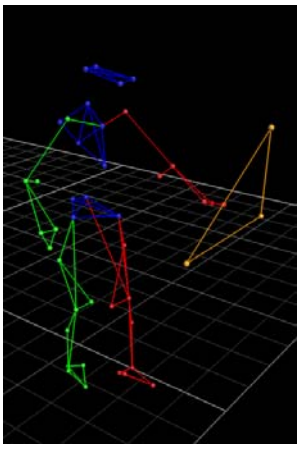
4 Combination of locomotion and upper limb movements

4.1 Pointing while walking on a treadmill

Partner	UniTu	
Task	Description	Participants were required to point to a virtual ball with the right hand while walking on a treadmill in a virtual reality environment
	Conditions	The ball appeared randomly in 9 different locations in space, all of them lying on a plane parallel to the subject's coronal plane. 5 reachings were collected for each target location. Target appearance was synchronised with heel strike.
	Subjects	Adults
Data	Motion capture system	Vicon (10 cameras), Oxford, UK. Capture frequency: 120 Hz.
	Virtual Reality System	Four Dolby 3D stereo projectors projecting on a cylindrical screen. Uses Horde3D for rendering.
	Marker positions 	• Left mid head (LMIDH) • 7th Cervical Vertebrae (C7) • 10th Thoracic Vertebrae (T10) • Clavicle (CLAV) • Sternum (STRN) • Right back shoulder blade (RBAK) Bilateral (left: L, right: R): • Front head (FHD) • Back head (BHD) • Shoulder (SHO) • Upper arm (UPA) • Elbow (ELB) • Forearm (FRA) • Wrist A (WRA) • Wrist B (WRB) • Finger (FIN) • ASIS (ASI) • IPSI (PSI) • Knee (KNE) • Thigh (THI) • Tibial wand marker (TIB) • Ankle (ANK) • Toe (TOE) • Heel (HEE) • 5th metatarsal bone (MT5)
Data storage format	Data file type	Vicon C3D (.c3d)

Sample data are available in the Datasets project of the AMARSi Collaboration Environment (https://redmine.amarsi-project.eu/documents/56).

4.2 Walking to and Opening a Drawer

Partner	UniBi	
Task	Description	Adult participants were required to walk up to a dresser drawer, open the drawer, grasp a cylinder within the drawer, and move the cylinder to a new location within the drawer. The height of the drawer was set equal to the distance from the participant's right posterior superior iliac spine to the floor.
	Conditions	Participants grasped the object inside the drawer from one of four possible locations (e.g., the four corners) and moved the object to a different corner location.
	Subjects	Adults
Data	Motion capture system	Vicon (12 cameras), Oxford, UK. Capture frequency: 200 Hz.
	Marker positions 	Upper Body: • Left front head (LFHD) • Right front head (RFHD) • Left back head (LBHD) • Right back head (RBHD) • 7th Cervical Vertebrae (C7) • 10th Thoracic Vertebrae (T10) • Clavicle (CLAV) • Sternum (STRN) • Right back shoulder blade (RBAK) Upper limb, bilateral: • Shoulder marker (SHO) • Elbow (ELB) • Proximal/Inner elbow (PELB) • Wrist marker thumb side (WRA) • Wrist marker pinkie side (WRB) • Finger, head of the second metacarpal (FIN) Lower Body, bilateral: • Anterior superior iliac spine (ASI) • Posterior superior iliac spine (SIS) • Thigh (THI) • Knee (KNE) • Inner knee (IKNEE) • Tibial (TIB) • Ankle (ANK) • Inner ankle (IANK) • Toe (TOE) • Heel (HEE)
Data storage format	Data file type	Vicon C3D (.c3d)

Sample data are available in the Datasets project of the AMARSi Collaboration Environment (https://redmine.amarsi-project.eu/documents/63).