MARKER PLACEMENT

Patient Preparation - see *6.4 Clinical Examination Protocol*

Models - standard marker placement protocol for:

• Lower body Plug-in-Gait (PiG)	19 mkrs	13 dynamic 4 wand (thigh x2, shank x2) 2 static
• Upper body Plug-in-Gait (UL PiG)	23 mrks	23 dynamic
• Oxford Trunk Model (OTM)	4 mkrs	3 dynamic 1 static (1 same as UL PiG)
• Oxford Foot Model (OFM)	24 mkrs	18 dynamic 2 wand (C-Peg x2) 4 static
• Knee and hip functional calibration	12 mkrs	12 dynamic (6 same as OFM)

Combined marker sets:

• PiG, functional	31 mkrs	25 dynamic 4 wand (thigh x2, shank x2) 2 static
• PiG, functional, OTM	35 mkrs	28 dynamic 4 wand (thigh x2, shank x2) 3 static
• PiG, OFM, functional	49 mkrs	37 dynamic 6 wands (thigh x2, shank x2, C-Peg x2) 6 static
• PiG, OFM, functional, OTM	53 mkrs	40 dynamic 6 wands (thigh x2, shank x2, C-Peg x2) 7 static

Description of each model's marker placement is below, with images at the end of the document.

Default models to use are: **Barefoot** **PiG, functional, OFM*** * OFM may not be possible for small and/or clammy feet

Shod **PiG, functional**

The text below for PiG is adapted from Vicon documentation. Where left side markers only are listed; the positioning is identical for the right side. Forefoot and anterior tibial markers are placed in sitting. All other markers, where possible are placed with the patient standing.

LOWER BODY PLUG-IN-GAIT (PiG)

Standard clinical marker set shown in bold; 19 markers total (2 removed for dynamic trials)

Pelvis markers

LASI	Left ASIS	Palpate from below anterior superior iliac spine. Place marker just above projection (lip) of ASIS.
LISH	Left iliac crest	Palpate along the iliac crest. Place marker at the midpoint between the SACR and LASI

In obese patients it can be difficult to place markers accurately on the ASIS and excessive soft tissue can obscure the markers. In this case, use the Hvidovre wand markers as a first option. If these will be knocked when walking, then move each ASIS marker laterally by an equal amount along the LASIS-RASIS axis. If it is not possible to move markers laterally without also moving them antero-posteriorally the ant-post ASIS to trochanter distance should be recorded and input into the model. The true inter-ASIS distance must then be recorded and entered on the PRF form.

SACR	Sacrum	Placed on the skin mid-way between the posterior superior iliac spines. Check positions of ASIS and SACR markers from the side, to make sure pelvic tilt represented by markers looks sensible.

If losing visibility of the sacral marker is a problem, a skin marker can be replaced by a 'wand marker' to extend the marker away from the body. In this case it must be positioned to lie in the plane formed by the ASIS and PSIS

Leg markers

LKNE	Left knee	Placed on the lateral epicondyle of the left knee

Make sure the knees are as straight as possible when placing the marker (and also in the static trial). Place marker on femoral epicondyle, mid-way between anterior and posterior surfaces of the leg (excluding the patella). Palpate up from the joint line (use the popliteal crease as an indicator of the joint line, particularly in over-weight patients). Check symmetry of marker heights from the front (taking into account any leg length discrepancy). If the patient is unable to extend their knee (ie in crouch position), then place the marker slightly more posteriorly. Beware of ITB/TFL, particularly in adult males – don't allow this to influence marker positioning.

LTHI	Left thigh wand marker	Place the marker over the lower lateral 1/3 surface of the thigh, just below the swing of the hand, although the height is not critical.

The thigh markers are used to calculate the knee flexion axis location and orientation. Place the marker over the lower lateral 1/3 surface of the thigh, just below the swing of the hand. The marker should be aligned in the plane that contains the hip and knee joint centers and the knee flexion/extension axis.

LANK	Left ankle	Placed on the most prominent point of the lateral malleolus along an imaginary line that passes through the transmalleolar axis. Use small base marker.
LTIB	Left tibial wand marker	This shank marker determines the alignment of the ankle flexion axis and is aligned by the software. Place the marker over the lower 1/3 lateral surface of shank approximately in the plane that contains the knee and ankle joint centres – i.e. lined up with the bi-malleolar axis, and not necessarily in line with LKNE.
LTOE	Left toe	Placed between the distal ends of the second and third metatarsals.
LHEE	Left heel	Placed in the middle of the calcaneus at the same height above the plantar surface of the foot as the toe marker. LTOE and LHEE used to calculate line of the foot for foot progression. *Note: if measuring subject in AFOs the heel marker should be in line with the heel of the foot which may be different to the heel of the AFO if there is a heel raise within the orthosis.*

The heel marker should be placed on the posterior aspect of the calcaneus, at the same height above the plantar surface of the foot as the toe marker. It should be aligned such that the line joining the heel and toe marker defines the progression of the foot in the transverse plane. This can be adjusted in the software if the subject is able to stand with their foot flat on the floor. If the heel is not flat on the floor this distance will need to be carefully measured.

LMMA (needed for static trial only)	Left medial malleolus	Placed on the most prominent point of the medial malleolus along an imaginary line that passes through the transmalleolar axis. Use small base marker.

Put both LANK and LMMA markers on simultaneously. This is used to define the knee/ankle axis, which is not necessarily the same as tibial torsion.

Anthropometric Measurements Required for Lower Body (to be entered on PRF form)

Height in standing (mm)	In the presence of significant hip and knee contractures measure 'true' height with tape measure in supine lying).
Weight (kg)	taken from force plates
Leg Length (mm)	Distance between ASIS and the most prominent point of the medial malleolus, via the medial aspect of the knee joint. Measure in supine lying. Method takes into account any contractures and is NOT therefore the shortest distance between the ASIS and medial malleolus.
Inter-ASIS distance (mm)	ASIS-ASIS distance - is the distance between the left ASIS and right ASIS.
Knee Width (mm)	The medio-lateral width of the knee across the line of the knee axis
Ankle Width (mm)	The medio-lateral distance across the malleoli. Note: if measuring subject in AFOs this should be taken as the external distance including the AFOs

Optional Subject Measurements for the Lower Body

If not entered this is calculated by the model

ASIS-Trochanter Distance (mm)	Vertical distance, in the sagittal plane, between the ASIS and greater trochanter when the subject is lying supine. Measure with the femur rotated such that the greater trochanter is positioned as lateral as possible. Only needed when markers cannot be placed directly on the ASIS.

UPPER BODY PLUG-IN-GAIT (UL PiG)

Not routinely used in OGL clinical protocol

Head Markers

LFHD	Left front head	Located approximately over the left temple
RFHD	Right front head	Located approximately over the right temple
LBHD	Left back head	Placed on the back of the head, roughly in a horizontal plane of the front head markers
RBHD	Right back head	Placed on the back of the head, roughly in a horizontal plane of the front head markers

The markers over the temples define the origin, and the scale of the head. The rear markers define its orientation. If they cannot be placed level with the front markers, and the head is level in the static trial, tick the "Head Level" check box under options on “Run static model” in the pipeline when processing the static trial. A headband with permanently attached markers may also be used.

Torso Markers

C7	7th cervical vertebrae	Spinous process of the 7th cervical vertebrae
T10	10th thoracic vertebrae	Spinous Process of the 10th thoracic vertebrae
CLAV	Clavicle	Jugular Notch where the clavicles meet the sternum
STRN	Sternum	Xiphoid process of the Sternum
RBAK	Right back	Placed in the middle of the right scapula. This marker has no symmetrical marker on the left side. This asymmetry helps the auto-labeling routine determine right from left on the subject.

C7, T10, CLAV, STRN define a plane hence their lateral positioning is most important.

Arm Markers

LSHO	Left shoulder	Placed on the Acromio-clavicular joint
LUPA	Left upper arm	Placed on the upper arm between the elbow and shoulder markers. Should be placed asymmetrically with RUPA
LELB	Left elbow	Placed on lateral epicondyle approximating elbow joint axis
LFRA	Left forearm	Placed on the lower arm between the wrist and elbow markers. Should be placed asymmetrically with RFRA
LWRA	Left wrist A	Left wrist bar thumb side, along wrist axis
LWRB	Left wrist B	Left wrist bar pinkie side, along wrist axis
LFIN	Left fingers	Actually placed on the dorsum of the hand just below the head of the second metacarpal

.

Required Subject Measurements for the Upper Body

Shoulder Offset (mm)	vertical offset from the base of the acromion marker to shoulder joint centre
Elbow Width (mm)	Width of elbow along flexion axis (roughly between the distal epicondyles of the humerus)
Wrist Width (mm)	Anterior/ Posterior thickness of wrist at position where wrist markers are attached
Hand Thickness (mm)	Anterior/ Posterior thickness between the dorsum and palmar surfaces of the hand.

OXFORD TRUNK MODEL (OTM)

The following markers are used in conjunction with the Plug-in-Gait lower body marker set.

T2	2nd thoracic vertebrae	Spinous process of the 2nd thoracic vertebrae
T6	6th thoracic vertebrae	Spinous Process of the 6th thoracic vertebrae
T12 (static only)	12th thoracic vertebrae	Spinous Process of the 12th thoracic vertebrae
CLAV	Clavicle	Jugular Notch where the clavicles meet the sternum

OXFORD FOOT MODEL (OFM)

The following markers are used in conjunction with the Plug-in-Gait lower body marker set.

Tibia markers

LHFB	Left head of fibula	Most lateral aspect of the head of fibula
LTUB	Left tibial tuberosity	Most anterior aspect of the tibial tuberosity
LSHN	Left shin	Anywhere on the anterior crest of the tibia

Hindfoot markers

LCPG	Left posterior calcaneus wand marker	Base is placed between LPCA and LHEE & its marker is in line with LPCA and LHEE, in line with coronal orientation of the hindfoot
LPCA (static only)	Left proximal calcaneus	Posterior aspect of calcaneus, proximal end of midline in sagittal plane
LLCA	Left lateral calcaneus	Lateral aspect of calcaneus at same distance from LHEE as LSTL and at same level from plantar surface of the foot as LSTL
LSTL	Left sustentaculum tali	Sustentaculum tali

Forefoot markers

LP1M	Left base of 1st metatarsal	Proximal head of 1st metatarsal, just medial to the extensor hallucis longus tendon (palpated by asking subject to dorsiflex hallux)
*** LP5M**	Left base of 5th metatarsal	Laterally over the base of the 5th metatarsal
*** LD1M (static only)**	Left head of 1st metatarsal	Medially on the head of the 1st metatarsal
*** LD5M**	Left head of 5th metatarsal	Laterally on the head of the 5th metatarsal
*** LHLX**	Left base of hallux	Medial side of the proximal phalanx of the hallux, mid-way between the inferior and superior surfaces

L1DM and L5DM are positioned such that their centres lie along the line through the distal heads of the 1st and 5th metatarsal heads.

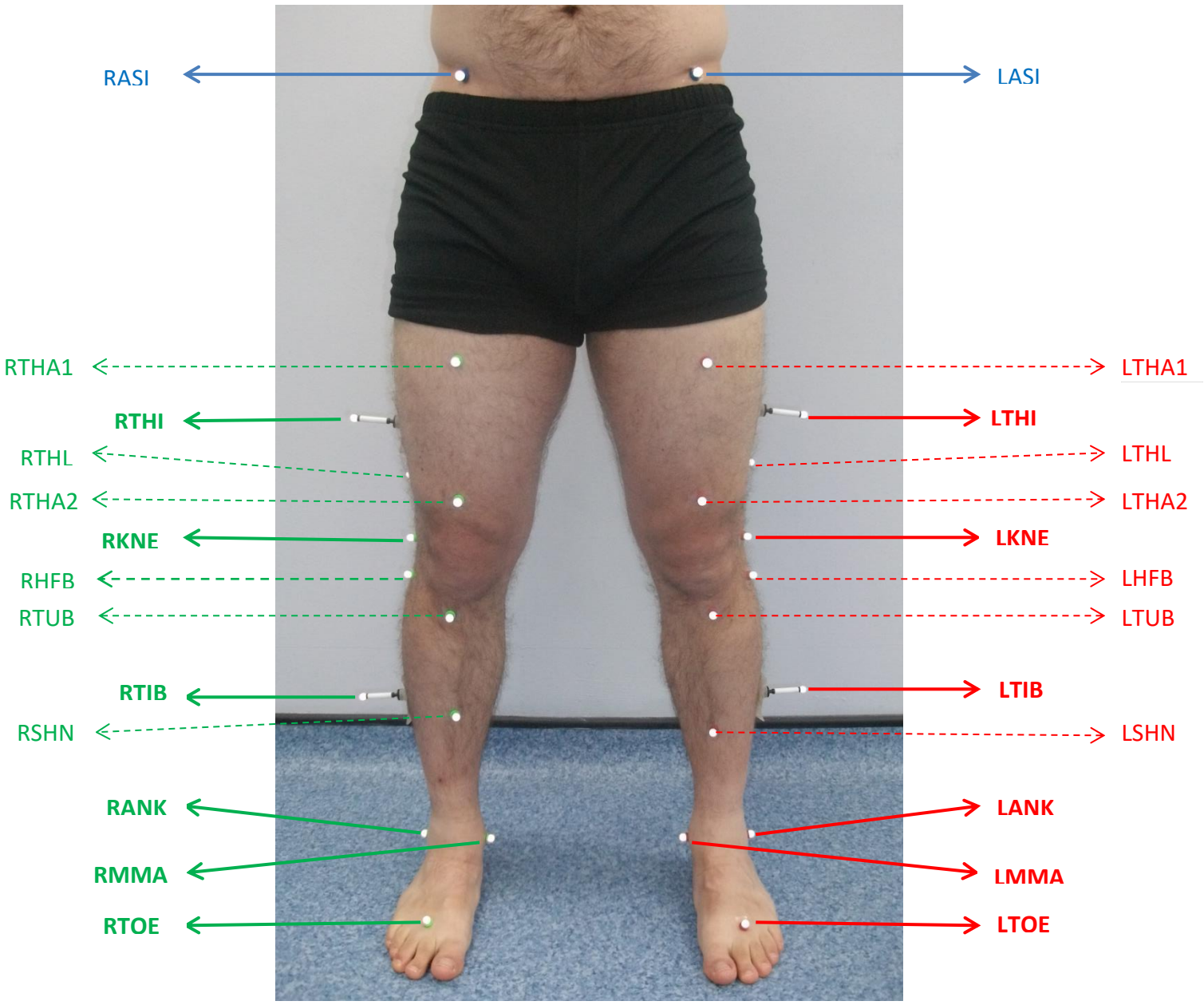
* LP5M, LD5M, LD1M and LHLX should all be equidistant from the plantar surface of the forefoot.

Functional markers should be placed in a triangular pattern to avoid co-linearity and placed as far apart as able within the confines of available space. This would normally take the format of a distal and proximal marker on the anterior thigh and a marker at the midpoint between the knee and thigh wand. The distal thigh marker should be placed above the patella so as not to be affected by knee motion.

Marker cleaning

Markers are cleaned once a week (or more regularly if required) by soaking them in hot water with washing up liquid; they are then rinsed and dried.

Images: PiG (lower limb) with functional markers



Functional Calibration Markers:

Markers to add to PiG model

R/L thigh anterior 1 = RTHA1 & LTHA1
R/L thigh anterior 2 = RTHA2 & LTHA2
R/L thigh lateral = RTHL & LTHL

R/L OFM fib. head = RHFB & LHFB
R/L OFM tib. tub. = RTUB & LTUB
L OFM shin = RSHN & LSHN

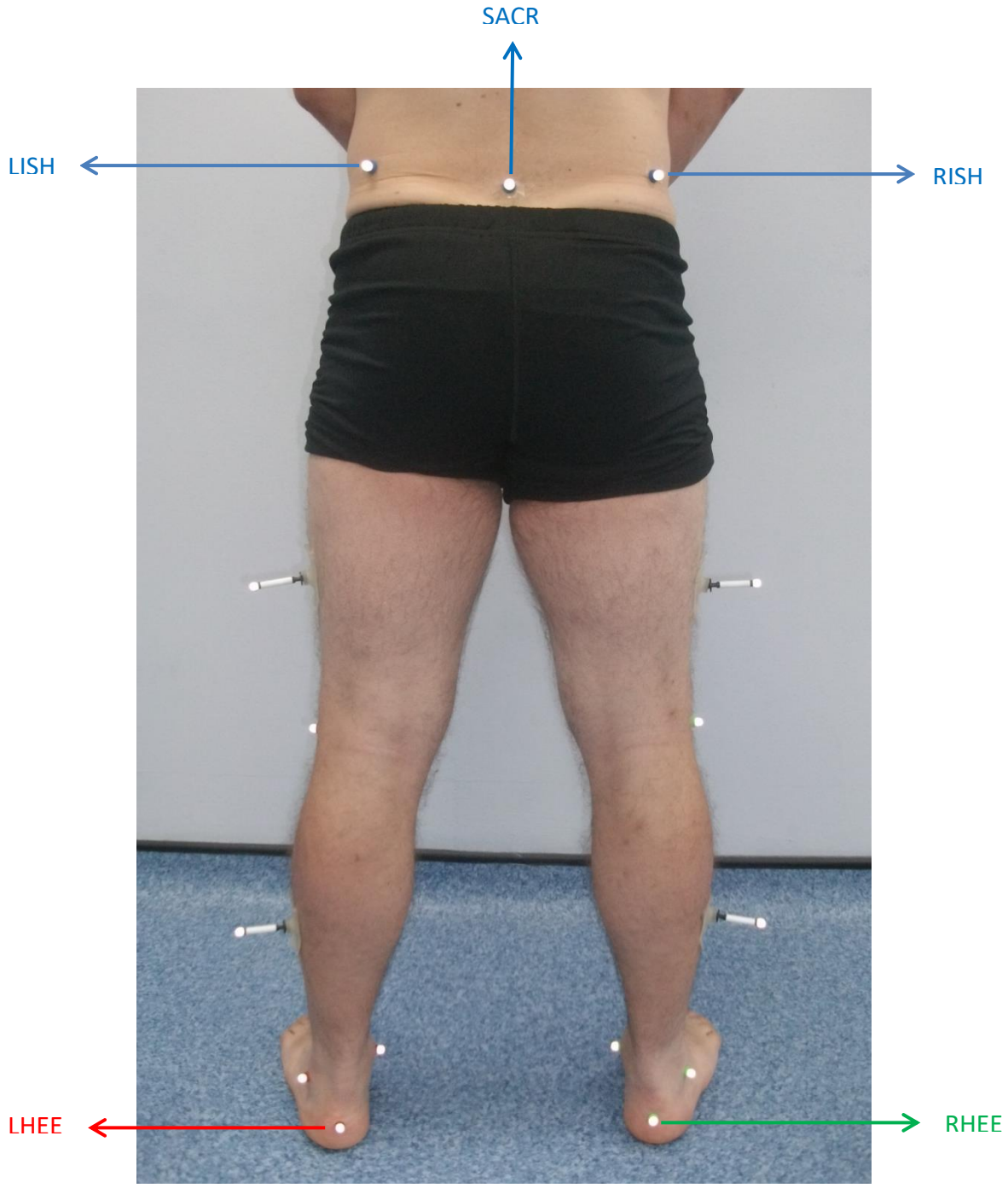
Markers to add to Oxford Foot Model

R/L thigh anterior 1 = RTHA1 & LTHA1
R/L thigh anterior 2 = RTHA2 & LTHA2
R/L thigh lateral = RTHL & LTHL

PiG markers

Functional markers

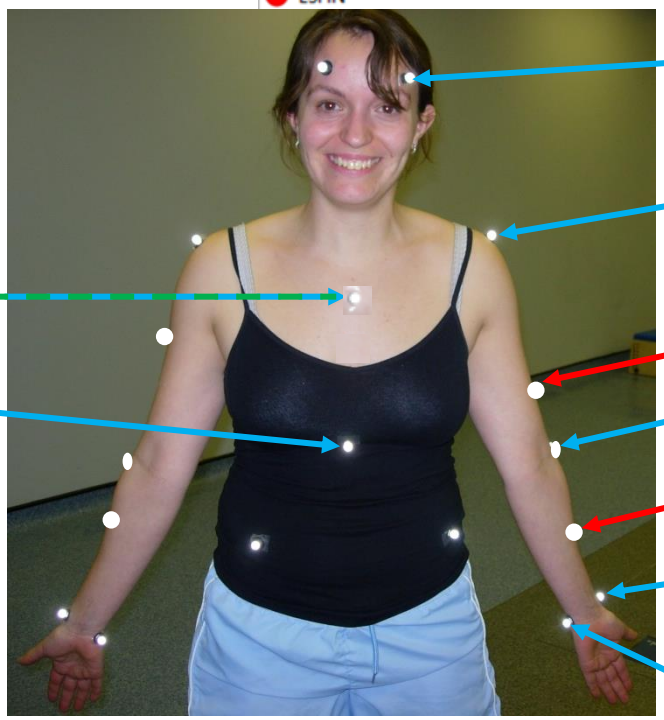
Images: PiG (lower limb) with functional markers

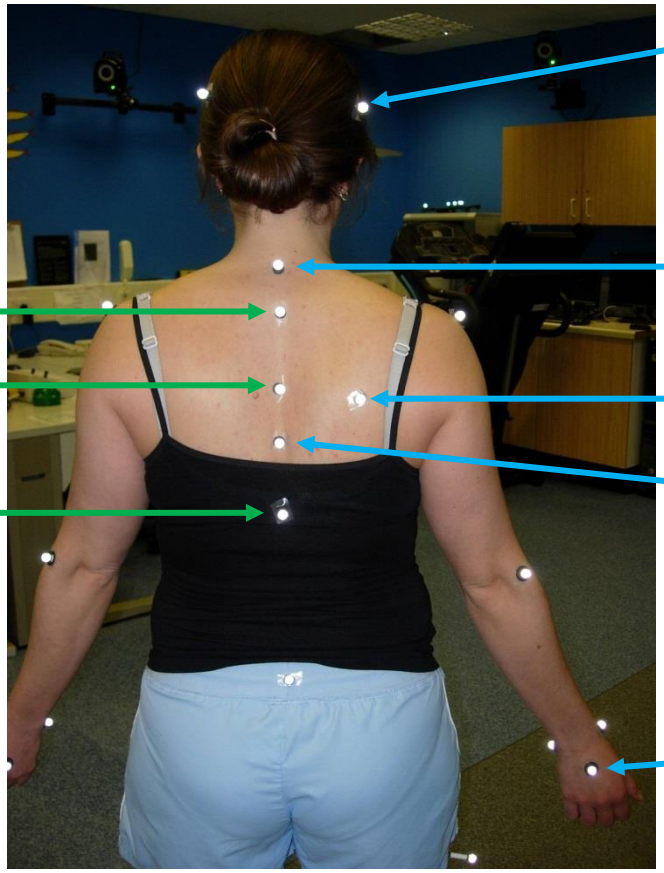


VST marker order

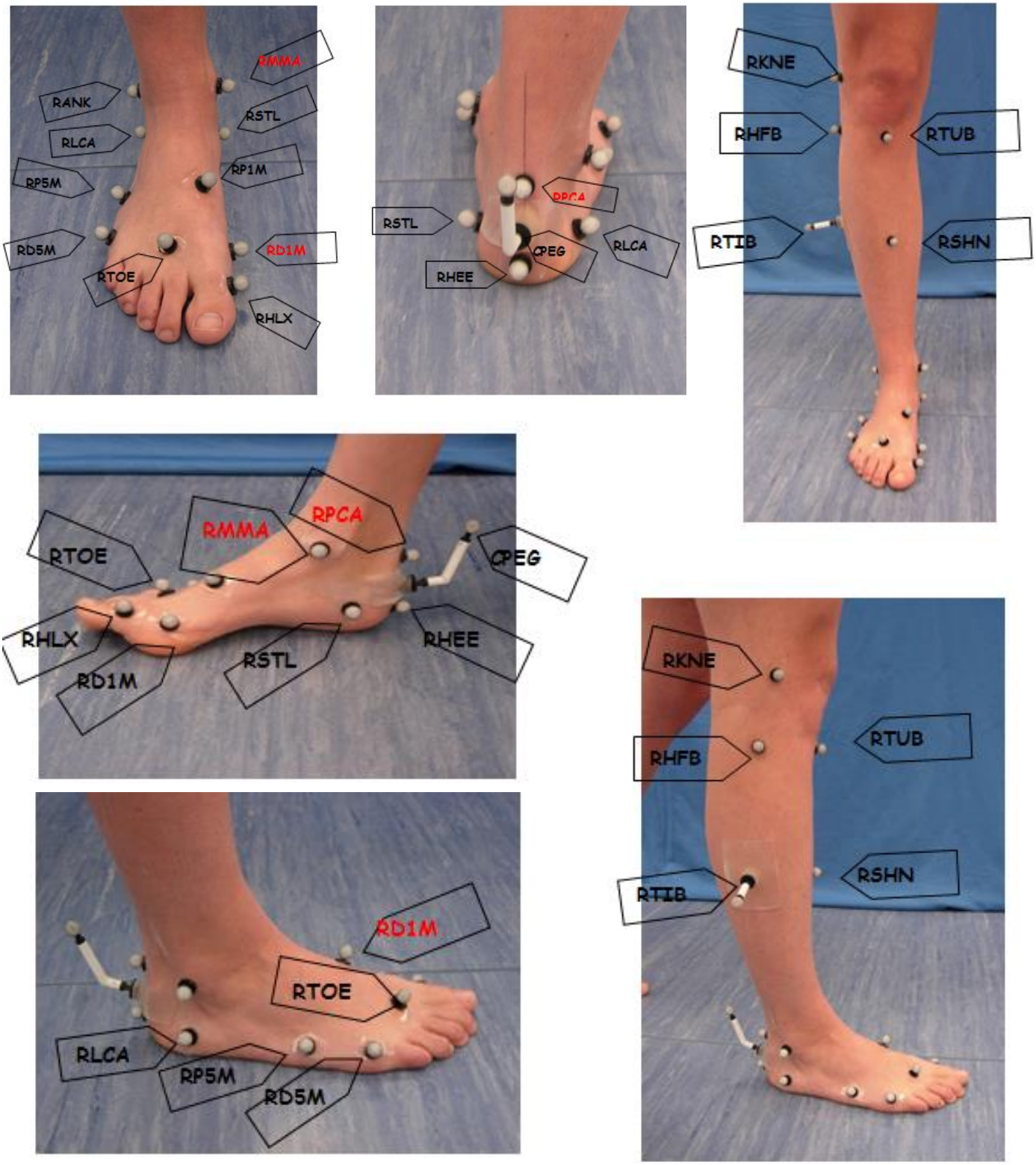
SACR
LASI
RASI
LTHI
LTHA1
LTHA2
LTHL
LKNE
LHFB
LTUB
LTIB
LSHN
RTHI
RTHA1
RTHA2
RTHL
RKNE
RHFB
RTUB
RTIB
RSHN

PiG Upper Limb (with extra UPA and FRM) and Oxford Trunk




RBHD
C7
T2
T6
RBAK
(right side only)
T10
T12
RFIN

Oxford Foot Model (OFM)



MARKERS IN RED ARE REMOVED AFTER STATIC TRIAL