clsa élcv
Canadian Longitudinal Study on Aging
Étude longitudinale canadienne sur le vieillissement

Whole Body DEXA Reanalysis (Baseline)

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1.0 INTRODUCTION

Baseline whole body DEXA scans were centrally re-analyzed by remote access to PC workstations running Apex v5.0.6.5 under Windows 7 32-bit operating system. Analysis was performed by trained staff of the MRC Epidemiology Unit, University of Cambridge. Reference documentation for whole body DEXA analysis as performed by this group can be found here: https://www.measurement-toolkit.org/anthropometry/objective-methods/whole-body-dexa-scan

2.0 DATA MANAGEMENT

Baseline scans were acquired on Hologic Horizon-A QDR scanners sited at each of the 11 CLSA data collection sites during the period spanning May 2012 to July 2015. Scans were exported in dicom format at the conclusion of participant interviews using open source data capture (Onyx, Maelstrom Research) and data warehousing software (Opal, Maelstrom Research) specially configured for CLSA use. In house web-based software (Salix) was developed as a data management and quality control (QC) system that integrates participant data and biographic information among the following elements:

1.0 Opal: interview data warehouse

2.0 Apex: scan import, display, re-analysis and export

3.0 ConquestDicom Server: dicom file server

4.0 MySQL Server: Apex database backend

5.0 Cenozo: CLSA participant management software

Salix performs the following tasks:

1.0 Retrieve meta data from Opal including scan availability, participant height, weight, gender, date of birth, ethnicity, interview identifier

2.0 Retrieve scan files in dicom format from Opal

3.0 Validate dicom tag values against Opal meta data (eg., PatientID = interview identifier etc.)

4.0 Deploy validated scans to Apex on PC workstations via ConquestDicom Server

5.0 Resolve participant biography inconsistencies between Opal or Cenozo and Apex

6.0 Track status of scan re-analysis (ie., pending, completed, exported)

7.0 Provide public facing web interface for quality control review process (eg., scan positioning faults, quality, pass or fail etc.)

A total of 28782 scans, deployed approximately equally among 3 workstations, were subjected to quality control review and re-analysis. Re-analysis and QC work occurred during the period spanning February 2018 to February 2020.

3.0 QUALITY ASSURANCE

Validated scans were opened for visualization and re-analysis in Apex. The following quality control codes were recorded via the Salix user interface:

Salix QC code/parameter	Description	Proposed Opal Variable
amputee	amputated limb(s)	QC_AMPUTEE
art(blur)	blurring artifact	QC_ART_BLUR
art(metal)	metal artifact	QC_ART_METAL
art(motion)	motion artifact	QC_ART_MOTION
art(noise)	noise or poor quality (grainy) image	QC_ART_NOISE
art(object)	object artifact	QC_ART_OBJECT
art(streak)	streak or banding artifact	QC_ART_STREAK
high	the ROI is placed too high and/or clipping of the lower anatomy	QC_ROI_HIGH
low	the ROI is placed too low and/or clipping of the upper anatomy	QC_ROI_LOW
left	the ROI is placed too far right and/or clipping of the anatomy along the left side of the ROI	QC_ROI_LEFT
right	the ROI is placed too far left and/or clipping of the anatomy along the right side of the ROI	QC_ROI_RIGHT
lines(arms)	the arm line(s) are improperly placed through the glenoid fossa	QC_LINES_ARMS
lines(legs)	the legs are improperly framed	QC_LINES_LEGS
lines(neck)	neck line is improperly placed	QC_LINES_NECK
Lines (pelvis)	the pelvis is improperly framed	QC_LINES_PELVIS
Lines (spine)	the spine is improperly framed and/or incorrect division between T12 and L1	QC_LINES_SPINE

Salix QC code/parameter	Description	Proposed Opal Variable
other	corrupt file or other condition	QC_OTHER
separation	insufficient separation or overlap of anatomy	QC_SEPARATION
Sym (left arm)	left arm symmetry computations required	QC_SYM_LEFT_ARM
Sym (right arm)	right arm symmetry computations required	QC_SYM_RIGHT_ARM
Sym (left ½ body)	left leg and arm symmetry computations required	QC_SYM_LEFT_HALF_BODY
Sym (right ½ body)	right leg and arm symmetry computations required	QC_SYM_RIGHT_HALF_BODY
status	pending, completed or exported	not applicable
pass	0 (fail) or 1 (pass)	QC_PASS
note	additional textual content	QC_NOTE

Table 1

Data dictionary

Hologic variables relating to body composition are stored in the MySQL Server database backend of Apex. The following database tables and variable names are provided herein. Note that all lean tissue variables represent fat free tissue: lean tissue including bone tissue. The exception applies to variables labelled with 'PURE_LEAN'. Whole body mass always represents the total tissue mass. For example, using Hologic variable names the following relationships apply:

1.0 WBTOT_LEAN = total fat free mass (includes lean and bone tissue)

2.0 WBTOT_MASS = WBTOT_FAT + WBTOT_LEAN

3.0 SUBTOT_LEAN = WBTOT_LEAN - HEAD_LEAN

4.0 TOTAL_PURE_LEAN = WBTOT_LEAN – WBTOT_BMC*

*not available for android and gynoid regions

Database Table Name	Variable Name	Proposed Opal Variable Name
PATIENT	IDENTIFIER1	BARCODE
ScanAnalysis	SCAN_DATE	SCAN_DATE
ScanAnalysis	ANALYSIS_DATE	ANALYSIS_DATE
PATIENT	BIRTHDATE	DOB
PATIENT	SEX	SEX

Database Table Name	Variable Name	Proposed Opal Variable Name
PATIENT	WEIGHT	WEIGHT
PATIENT	HEIGHT	HEIGHT
PATIENT	ETHNICITY	ETHNICITY
ScanAnalysis	SERIAL_NUMBER	SERIAL_NUMBER
ScanAnalysis	SCANID	SCANID
ScanAnalysis	SCAN_MODE	SCAN_MODE
Wbody	WBTOT_AREA	WB_WBTOT_AREA
Wbody	WBTOT_BMC	WB_WBTOT_BMC
Wbody	WBTOT_BMD	WB_WBTOT_BMD
Wbody	SUBTOT_AREA	WB_SUBTOT_AREA
Wbody	SUBTOT_BMC	WB_SUBTOT_BMC
Wbody	SUBTOT_BMD	WB_SUBTOT_BMD
Wbody	HEAD_AREA	WB_HEAD_AREA
Wbody	HEAD_BMC	WB_HEAD_BMC
Wbody	HEAD_BMD	WB_HEAD_BMD
Wbody	LARM_AREA	WB_LARM_AREA
Wbody	LARM_BMC	WB_LARM_BMC
Wbody	LARM_BMD	WB_LARM_BMD
Wbody	RARM_AREA	WB_RARM_AREA
Wbody	RARM_BMC	WB_RARM_BMC
Wbody	RARM_BMD	WB_RARM_BMD
Wbody	LRIB_AREA	WB_LRIB_AREA
Wbody	LRIB_BMC	WB_LRIB_BMC
Wbody	LRIB_BMD	WB_LRIB_BMD
Wbody	RRIB_AREA	WB_RRIB_AREA
Wbody	RRIB_BMC	WB_RRIB_BMC
Wbody	RRIB_BMD	WB_RRIB_BMD
Wbody	T_S_AREA	WB_T_S_AREA
Wbody	T_S_BMC	WB_T_S_BMC
Wbody	T_S_BMD	WB_T_S_BMD
Wbody	L_S_AREA	WB_L_S_AREA
Wbody	L_S_BMC	WB_L_S_BMC
Wbody	L_S_BMD	WB_L_S_BMD
Wbody	PELV_AREA	WB_PELV_AREA
Wbody	PELV_BMC	WB_PELV_BMC
Wbody	PELV_BMD	WB_PELV_BMD
Wbody	LLEG_AREA	WB_LLEG_AREA

Database Table Name	Variable Name	Proposed Opal Variable Name
Wbody	LLEG_BMC	WB_LLEG_BMC
Wbody	LLEG_BMD	WB_LLEG_BMD
Wbody	RLEG_AREA	WB_RLEG_AREA
Wbody	RLEG_BMC	WB_RLEG_BMC
Wbody	RLEG_BMD	WB_RLEG_BMD
WbodyComposition	FAT_STD	WBC_FAT_STD
WbodyComposition	LEAN_STD	WBC_LEAN_STD
WbodyComposition	BRAIN_FAT	WBC_BRAIN_FAT
WbodyComposition	WATER_LBM	WBC_WATER_LBM
WbodyComposition	HEAD_FAT	WBC_HEAD_FAT
WbodyComposition	HEAD_LEAN	WBC_HEAD_LEAN
WbodyComposition	HEAD_MASS	WBC_HEAD_MASS
WbodyComposition	HEAD_PFAT	WBC_HEAD_PFAT
WbodyComposition	LARM_FAT	WBC_LARM_FAT
WbodyComposition	LARM_LEAN	WBC_LARM_LEAN
WbodyComposition	LARM_MASS	WBC_LARM_MASS
WbodyComposition	LARM_PFAT	WBC_LARM_PFAT
WbodyComposition	RARM_FAT	WBC_RARM_FAT
WbodyComposition	RARM_LEAN	WBC_RARM_LEAN
WbodyComposition	RARM_MASS	WBC_RARM_MASS
WbodyComposition	RARM_PFAT	WBC_RARM_PFAT
WbodyComposition	TRUNK_FAT	WBC_TRUNK_FAT
WbodyComposition	TRUNK_LEAN	WBC_TRUNK_LEAN
WbodyComposition	TRUNK_MASS	WBC_TRUNK_MASS
WbodyComposition	TRUNK_PFAT	WBC_TRUNK_PFAT
WbodyComposition	L_LEG_FAT	WBC_L_LEG_FAT
WbodyComposition	L_LEG_LEAN	WBC_L_LEG_LEAN
WbodyComposition	L_LEG_MASS	WBC_L_LEG_MASS
WbodyComposition	L_LEG_PFAT	WBC_L_LEG_PFAT
WbodyComposition	R_LEG_FAT	WBC_R_LEG_FAT
WbodyComposition	R_LEG_LEAN	WBC_R_LEG_LEAN
WbodyComposition	R_LEG_MASS	WBC_R_LEG_MASS
WbodyComposition	R_LEG_PFAT	WBC_R_LEG_PFAT
WbodyComposition	SUBTOT_FAT	WBC_SUBTOT_FAT
WbodyComposition	SUBTOT_LEAN	WBC_SUBTOT_LEAN
WbodyComposition	SUBTOT_MASS	WBC_SUBTOT_MASS
WbodyComposition	SUBTOT_PFAT	WBC_SUBTOT_PFAT

Database Table Name	Variable Name	Proposed Opal Variable Name
WbodyComposition	WBTOT_FAT	WBC_WBTOT_FAT
WbodyComposition	WBTOT_LEAN	WBC_WBTOT_LEAN
WbodyComposition	WBTOT_MASS	WBC_WBTOT_MASS
WbodyComposition	WBTOT_PFAT	WBC_WBTOT_PFAT
ObesityIndices	FAT_STD	OI_FAT_STD
ObesityIndices	LEAN_STD	OI_LEAN_STD
ObesityIndices	BRAIN_FAT	OI_BRAIN_FAT
ObesityIndices	WATER_LBM	OI_WATER_LBM
ObesityIndices	TOTAL_PERCENT_FAT	OI_TOTAL_PERCENT_FAT
ObesityIndices	BODY_MASS_INDEX	OI_BODY_MASS_INDEX
ObesityIndices	ANDROID_GYNOID_RATIO	OI_ANDROID_GYNOID_RATIO
ObesityIndices	ANDROID_PERCENT_FAT	OI_ANDROID_PERCENT_FAT
ObesityIndices	GYNOID_PERCENT_FAT	OI_GYNOID_PERCENT_FAT
ObesityIndices	FAT_MASS_RATIO	OI_FAT_MASS_RATIO
ObesityIndices	TRUNK_LIMB_FAT_MASS_RATIO	OI_TRUNK_LIMB_FAT_MASS_RATIO
ObesityIndices	FAT_MASS_HEIGHT_SQUARED	OI_FAT_MASS_HEIGHT_SQUARED
ObesityIndices	TOTAL_FAT_MASS	OI_TOTAL_FAT_MASS
ObesityIndices	LEAN_MASS_HEIGHT_SQUARED	OI_LEAN_MASS_HEIGHT_SQUARED
ObesityIndices	APPENDAGE_LEAN_MASS_HEIGHT_2	OI_APPENDAGE_LEAN_MASS_HEIGHT_2
ObesityIndices	TOTAL_LEAN_MASS	OI_TOTAL_LEAN_MASS
ObesityIndices	PURE_LEAN_HEIGHT_SQUARED	OI_PURE_LEAN_HEIGHT_SQUARED
ObesityIndices	APPENDAGE_PURE_LEAN_HEIGHT_2	OI_APPENDAGE_PURE_LEAN_HEIGHT_2
ObesityIndices	TOTAL_PURE_LEAN	OI_TOTAL_PURE_LEAN
AndroidGynoidComposition	FAT_STD	AGC_FAT_STD
AndroidGynoidComposition	LEAN_STD	AGC_LEAN_STD
AndroidGynoidComposition	BRAIN_FAT	AGC_BRAIN_FAT
AndroidGynoidComposition	WATER_LBM	AGC_WATER_LBM
AndroidGynoidComposition	TISSUE_ANALYSIS_METHOD	AGC_TISSUE_ANALYSIS_METHOD

Database Table Name	Variable Name	Proposed Opal Variable Name
AndroidGynoidComposition	ROI_TYPE	AGC_ROI_TYPE
AndroidGynoidComposition	ROI_WIDTH	AGC_ROI_WIDTH
AndroidGynoidComposition	ROI_HEIGHT	AGC_ROI_HEIGHT
AndroidGynoidComposition	TOTAL_FAT	AGC_TOTAL_FAT
AndroidGynoidComposition	TOTAL_LEAN	AGC_TOTAL_LEAN
AndroidGynoidComposition	TOTAL_MASS	AGC_TOTAL_MASS
AndroidGynoidComposition	TOTAL_PFAT	AGC_TOTAL_PFAT
AndroidGynoidComposition	ANDROID_NAME	AGC_ANDROID_NAME
AndroidGynoidComposition	ANDROID_FAT	AGC_ANDROID_FAT
AndroidGynoidComposition	ANDROID_LEAN	AGC_ANDROID_LEAN
AndroidGynoidComposition	ANDROID_MASS	AGC_ANDROID_MASS
AndroidGynoidComposition	ANDROID_PFAT	AGC_ANDROID_PFAT
AndroidGynoidComposition	GYNOID_NAME	AGC_GYNOID_NAME
AndroidGynoidComposition	GYNOID_FAT	AGC_GYNOID_FAT
AndroidGynoidComposition	GYNOID_LEAN	AGC_GYNOID_LEAN
AndroidGynoidComposition	GYNOID_MASS	AGC_GYNOID_MASS
AndroidGynoidComposition	GYNOID_PFAT	AGC_GYNOID_PFAT
AndroidGynoidComposition	VFAT_BODY_FAT	AGC_VFAT_BODY_FAT
AndroidGynoidComposition	VFAT_BODY_LEAN	AGC_VFAT_BODY_LEAN
AndroidGynoidComposition	VFAT_BODY_MASS	AGC_VFAT_BODY_MASS

Database Table Name	Variable Name	Proposed Opal Variable Name
AndroidGynoidComposition	VFAT_BODY_PFAT	AGC_VFAT_BODY_PFAT
AndroidGynoidComposition	VFAT_OUTERWALL_FAT	AGC_VFAT_OUTERWALL_FAT
AndroidGynoidComposition	VFAT_OUTERWALL_LEAN	AGC_VFAT_OUTERWALL_LEAN
AndroidGynoidComposition	VFAT_OUTERWALL_MASS	AGC_VFAT_OUTERWALL_MASS
AndroidGynoidComposition	VFAT_OUTERWALL_PFAT	AGC_VFAT_OUTERWALL_PFAT
AndroidGynoidComposition	VFAT_CAVITY_FAT	AGC_VFAT_CAVITY_FAT
AndroidGynoidComposition	VFAT_CAVITY_LEAN	AGC_VFAT_CAVITY_LEAN
AndroidGynoidComposition	VFAT_CAVITY_MASS	AGC_VFAT_CAVITY_MASS
AndroidGynoidComposition	VFAT_CAVITY_PFAT	AGC_VFAT_CAVITY_PFAT
AndroidGynoidComposition	VFAT_AREA	AGC_VFAT_AREA
AndroidGynoidComposition	VFAT_MASS	AGC_VFAT_MASS
AndroidGynoidComposition	VFAT_VOLUME	AGC_VFAT_VOLUME
AndroidGynoidComposition	TAT_AREA	AGC_TAT_AREA
AndroidGynoidComposition	TAT_MASS	AGC_TAT_MASS
AndroidGynoidComposition	TAT_VOLUME	AGC_TAT_VOLUME
AndroidGynoidComposition	SAT_AREA	AGC_SAT_AREA
AndroidGynoidComposition	SAT_MASS	AGC_SAT_MASS
AndroidGynoidComposition	SAT_VOLUME	AGC_SAT_VOLUME
AndroidGynoidComposition	WAIST_CIRCUMFERENCE	AGC_WAIST_CIRCUMFERENCE
AndroidGynoidComposition	SUBCU_FAT_CORRECTION	AGC_SUBCU_FAT_CORRECTION

Database Table Name	Variable Name	Proposed Opal Variable Name
AndroidGynoidComposition	BODY_WIDTH	AGC_BODY_WIDTH
AndroidGynoidComposition	OUTER_WALL_WIDTH	AGC_OUTER_WALL_WIDTH
AndroidGynoidComposition	CAVITY_WIDTH	AGC_CAVITY_WIDTH

Table 2

Symmetry Calculations and Derived Variables

For those scans wherein appendages are positioned outside the scan boundary, a symmetry computation can be employed wherein the opposing (complete) side anatomy is substituted for missing or clipped anatomy. It was decided to bypass the Hologic symmetry functionality available within Apex in favor of a post data retrieval computation process. Using the symmetry codes noted in Table 1, formulae were developed incorporating Apex variables defined in Table 2 to arrive at a set of derived variables. A script has been developed that takes input data from Apex (appendix A.1) and symmetry codes (appendix A.2) from Salix and outputs original, symmetry and derived variable values.

Derived Variable	Formula	Symmetry Conditions
SYM_WB_RARM_BMC	WB_LARM_BMC	sym(right arm)|sym(right ½ body)
SYM_WB_RARM_AREA	WB_LARM_AREA	sym(right arm)|sym(right ½ body)
SYM_WB_RARM_BMD	WB_LARM_BMD	sym(right arm)|sym(right ½ body)
SYM_WB_LARM_BMC	WB_RARM_BMC	sym(left arm)|sym(left ½ body)
SYM_WB_LARM_AREA	WB_RARM_AREA	sym(left arm)|sym(left ½ body)
SYM_WB_LARM_BMD	WB_RARM_BMD	sym(left arm)|sym(left ½ body)
SYM_WB_RLEG_BMC	WB_LLEG_BMC	sym(right ½ body)
SYM_WB_RLEG_AREA	WB_LLEG_AREA	sym(right ½

Derived Variable	Formula	Symmetry Conditions
		body)
SYM_WB_RLEG_BMD	WB_LLEG_BMD	sym(right ½ body)
SYM_WB_LLEG_BMC	WB_RLEG_BMC	sym(left ½ body)
SYM_WB_LLEG_AREA	WB_RLEG_AREA	sym(left ½ body)
SYM_WB_LLEG_BMD	WB_RLEG_BMD	sym(left ½ body)
SYM_WB_WBTOT_BMC	WB_WBTOT_BMC – WB_LARM_BMC + WB_RARM_BMC	sym(left arm)|sym(left ½ body)
SYM_WB_WBTOT_BMC	WB_WBTOT_BMC – WB_RARM_BMC + WB_LARM_BMC	sym(right arm)|sym(right ½ body)
SYM_WB_WBTOT_AREA	WB_WBTOT_AREA – WB_LARM_AREA + WB_RARM_AREA	sym(left arm)|sym(left ½ body)
SYM_WB_WBTOT_AREA	WB_WBTOT_AREA – WB_RARM_AREA + WB_LARM_AREA	sym(right arm)|sym(right ½ body)
SYM_WB_WBTOT_BMD	WB_WBTOT_BMD – WB_LARM_BMD + WB_RARM_BMD	sym(left arm)|sym(left ½ body)
SYM_WB_WBTOT_BMD	WB_WBTOT_BMD – WB_RARM_BMD + WB_LARM_BMD	sym(right arm)|sym(right ½ body)
SYM_WB_SUBTOT_BMC	SYM_WB_WBTOT_BMC – WB_HEAD_BMC	all
SYM_WB_SUBTOT_AREA	SYM_WB_WBTOT_AREA – WB_HEAD_AREA	all
SYM_WB_SUBTOT_BMD	SYM_WB_WBTOT_BMD – WB_HEAD_BMD	all
SYM_WBC_RARM_MASS	WBC_LARM_MASS	sym(right arm)|sym(right ½ body)
SYM_WBC_RARM_FAT	WBC_LARM_FAT	sym(right arm)|sym(right ½ body)
SYM_WBC_RARM_LEAN	WBC_LARM_LEAN	sym(right arm)|sym(right ½ body)

Derived Variable	Formula	Symmetry Conditions
SYM_WBC_RARM_PFAT	WBC_LARM_PFAT	sym(right arm)|sym(right ½ body)
SYM_WBC_LARM_MASS	WBC_RARM_MASS	sym(left arm)|sym(left ½ body)
SYM_WBC_LARM_FAT	WBC_RARM_FAT	sym(left arm)|sym(left ½ body)
SYM_WBC_LARM_LEAN	WBC_RARM_LEAN	sym(left arm)|sym(left ½ body)
SYM_WBC_LARM_PFAT	WBC_RARM_PFAT	sym(left arm)|sym(left ½ body)
SYM_WBC_R_LEG_MASS	WBC_L_LEG_MASS	sym(right ½ body)
SYM_WBC_R_LEG_FAT	WBC_L_LEG_FAT	sym(right ½ body)
SYM_WBC_R_LEG_LEAN	WBC_L_LEG_LEAN	sym(right ½ body)
SYM_WBC_R_LEG_PFAT	WBC_L_LEG_PFAT	sym(right ½ body)
SYM_WBC_L_LEG_MASS	WBC_R_LEG_MASS	sym(left ½ body)
SYM_WBC_L_LEG_FAT	WBC_R_LEG_FAT	sym(left ½ body)
SYM_WBC_L_LEG_LEAN	WBC_R_LEG_LEAN	sym(left ½ body)
SYM_WBC_L_LEG_PFAT	WBC_R_LEG_PFAT	sym(left ½ body)
SYM_WBC_WBTOT_MASS	WBC_WBTOT_MASS – WBC_LARM_MASS + WBC_RARM_MASS	sym(left arm)|sym(left ½ body)
SYM_WBC_WBTOT_FAT	WBC_WBTOT_FAT– WBC_LARM_FAT + WBC_RARM_FAT	sym(left arm)|sym(left ½ body)
SYM_WBC_WBTOT_LEAN	WBC_WBTOT_LEAN – WBC_LARM_LEAN + WBC_RARM_LEAN	sym(left arm)|sym(left ½ body)
SYM_WBC_WBTOT_MASS	WBC_WBTOT_MASS – WBC_RARM_MASS +	sym(right arm)|sym(rig

Derived Variable	Formula	Symmetry Conditions
	WBC_LARM_MASS	ht ½ body)
SYM_WBC_WBTOT_FAT	WBC_WBTOT_FAT– WBC_RARM_FAT + WBC_LARM_FAT	sym(right arm)|sym(right ½ body)
SYM_WBC_WBTOT_LEAN	WBC_WBTOT_LEAN – WBC_RARM_LEAN + WBC_LARM_LEAN	sym(right arm)|sym(right ½ body)
SYM_WBC_WBTOT_PFAT	100 x SYM_WBC_WBTOT_FAT / SYM_WBC_WBTOT_MASS	all
SYM_WBC_SUBTOT_MASS	SYM_WBC_WBTOT_MASS – WBC_HEAD_MASS	all
SYM_WBC_SUBTOT_FAT	SYM_WBC_WBTOT_FAT – WBC_HEAD_FAT	all
SYM_WBC_SUBTOT_LEAN	SYM_WBC_WBTOT_LEAN – WBC_HEAD_LEAN	all
SYM_WBC_SUBTOT_PFAT	100 x SYM_WBC_SUBTOT_FAT / SYM_WBC_SUBTOT_MASS	all
SYM_OI_TOTAL_LEAN_MASS	SYM_WBC_WBTOT_LEAN	all
SYM_OI_TOTAL_PURE_LEAN	SYM_WBC_WBTOTAL_MASS – SYM_WB_WBTOT_BMC	all
SYM_OI_TOTAL_FAT_MASS	SYM_WBC_WBTOT_FAT	all
SYM_OI_TOTAL_PERCENT_FAT	SYM_WBC_WBTOT_PFAT	all
SYM_OI_FAT_MASS_RATIO	WBC_TRUNK_PFAT / WBC_R_LEG_PFAT	sym(left arm)|sym(left ½ body)
SYM_OI_FAT_MASS_RATIO	WBC_TRUNK_PFAT / WBC_L_LEG_PFAT	sym(right arm)|sym(right ½ body)
SYM_OI_TRUNK_LIMB_FAT_MASS_RATIO	WBC_TRUNK_FAT / 2 x (WBC_RARM_FAT + WBC_R_LEG_FAT)	sym(left arm)|sym(left ½ body)
SYM_OI_TRUNK_LIMB_FAT_MASS_RATIO	WBC_TRUNK_FAT / 2 x (WBC_LARM_FAT + WBC_L_LEG_FAT)	sym(right arm)|sym(right ½ body)
SYM_OI_FAT_MASS_HEIGHT_SQUARED	10 x SYM_WBC_WBTOT_FAT / H2	all
SYM_OI_LEAN_MASS_HEIGHT_SQUARED	10 x SYM_WBC_WBTOT_LEAN / H2	all
SYM_OI_APPENDAGE_LEAN_MASS_HEIGHT_2	20 x (WBC_RARM_LEAN + WBC_R_LEG_LEAN) / H2	sym(left arm)|sym(left

Derived Variable	Formula	Symmetry Conditions
		½ body)
SYM_OI_APPENDAGE_LEAN_MASS_HEIGHT_2	20 x (WBC_LARM_LEAN + WBC_L_LEG_LEAN) / H2	sym(right arm)|sym(right ½ body)
SYM_OI_PURE_LEAN_HEIGHT_SQUARED	10 x SYM_OI_TOTAL_PURE_LEAN / H2	all
SYM_OI_APPENDAGE_PURE_LEAN_HEIGHT_2	20 x (WBC_RARM_LEAN – WB_RARM_BMC + WBC_R_LEG_LEAN – WB_RLEG_BMC) / H2	sym(left arm)|sym(left ½ body)
SYM_OI_APPENDAGE_PURE_LEAN_HEIGHT_2	20 x (WBC_LARM_LEAN – WB_LARM_BMC + WBC_L_LEG_LEAN – WB_LLEG_BMC) / H2	sym(right arm)|sym(right ½ body)
DRV_LARM_PURE_LEAN	WBC_LARM_LEAN – WB_LARM_BMC	
DRV_RARM_PURE_LEAN	WBC_RARM_LEAN – WB_RARM_BMC	
DRV_L_LEG_PURE_LEAN	WBC_L_LEG_LEAN – WB_LLEG_BMC	
DRV_R_LEG_PURE_LEAN	WBC_R_LEG_LEAN – WB_RLEG_BMC	
DRV_HEAD_PURE_LEAN	WBC_HEAD_LEAN – WB_HEAD_BMC	
DRV_TRUNK_BMC	WB_LRIB_BMC + WB_RRIB_BMC _ WB_T_S_BMC + WB_L_S_BMC + WB_PELV_BMC	
DRV_TRUNK_PURE_LEAN	WBC_TRUNK_LEAN – WB_LRIB_BMC – WB_RRIB_BMC _ WB_T_S_BMC – WB_L_S_BMC – WB_PELV_BMC	
DRV_SUBTOT_PURE_LEAN	WBC_SUBTOT_LEAN – WB_SUBTOT_BMC	
DRV_APPENDAGE_PURE_LEAN	DRV_LARM_PURE_LEAN + DRV_RARM_PURE_LEAN + DRV_L_LEG_PURE_LEAN + DRV_R_LEG_PURE_LEAN	
SYM_DRV_LARM_PURE_LEAN	WBC_RARM_LEAN –	sym(left

Derived Variable	Formula	Symmetry Conditions
	WB_RARM_BMC	arm)|sym(left ½ body)
SYM_DRV_RARM_PURE_LEAN	WBC_LARM_LEAN – WB_LARM_BMC	sym(right arm)|sym(right ½ body)
SYM_DRV_L_LEG_PURE_LEAN	WBC_R_LEG_LEAN – WB_RLEG_BMC	sym(left arm)|sym(left ½ body)
SYM_DRV_R_LEG_PURE_LEAN	WBC_L_LEG_LEAN – WB_LLEG_BMC	sym(right arm)|sym(right ½ body)
SYM_DRV_SUBTOT_PURE_LEAN	SYM_WBC_SUBTOT_LEAN – SYM_WB_SUBTOT_BMC	all
SYM_DRV_APPENDAGE_PURE_LEAN	SYM_DRV_LARM_PURE_LEAN + SYM_DRV_RARM_PURE_LEAN + SYM_DRV_L_LEG_PURE_LEAN + SYM_DRV_R_LEG_PURE_LEAN	all

Table 3

Recommended Variables

For body composition, it is standard to use fat, lean, bone and fat free mass. Table 4 provides the equivalency relationships of Hologic to body composition variables as well as proposed variable names (excluding symmetry derived names).

Body Composition: WB_WBTOT_FAT, OI_TOTAL_PURE_LEAN, WB_WBTOT_BMC

Segmental Body Composition: WBC_HEAD_FAT, DRV_HEAD_PURE_LEAN, WB_HEAD_BMC, WBC_LARM_FAT, DRV_LARM_PURE_LEAN, WB_LARM_BMC, WBC_RARM_FAT, DRV_RARM_PURE_LEAN, WB_RARM_BMC, WBC_TRUNK_FAT, DRV_TRUNK_PURE_LEAN, DRV_TRUNK_BMC, WBC_L_LEG_FAT, DRV_L_LEG_PURE_LEAN, WB_L_LEG_BMC, WBC_R_LEG_FAT, DRV_R_LEG_PURE_LEAN, WB_RLEG_BMC

Central Body Composition: AGC_ANDROID_FAT, AGC_ANDROID_LEAN, AGC_GYNOID_FAT, AGC_GYNOID_LEAN

Visceral Fat Estimation Central Body Composition (VAT / SCAT): AGC_VFAT_AREA, AGC_VFAT_MASS, AGC_VFAT_VOLUME, AGC_SAT_AREA, AGC_SAT_MASS, AGC_SAT_VOLUME

The VAT and SCAT areas are the only variables validated against single slice computer tomography. The volume and mass variables are derived from the validated areas. It is assumed that volume is derived by multiplying the area against the height of the visceral area on the scan, to derive mass variables the volume is multiplied by 0.9 (density of adipose tissue in cm3) (Ross R, Léger L, Guardo R, De Guise J, Pike BG 1991 Adipose tissue volume measured by magnetic resonance imaging and computerized tomography in rats. J Appl Physiol 70: 2164–2172). GE Medical Systems offers dexa technology, notably with their Lunar systems.

Description	Proposed Names	Hologic
Total BMC	WB_WBTOT_BMC	WBTOT_BMC
Total BMD	WB_WBTOT_BMD	WBTOT_BMD
Head fat mass	WBC_HEAD_FAT	HEAD_FAT
Head lean mass	DRV_HEAD_LEAN	HEAD_LEAN - HEAD_BMC
Head bone mass	WB_HEAD_BMC	HEAD_BMC
Left arm fat mass	WBC_LARM_FAT	LARM_FAT
Left arm lean mass	DRV_LARM_LEAN	LARM_LEAN - LARM_BMC
Left arm bone mass	WBC_LARM_BMC	LARM_BMC
Right arm fat mass	WBC_RARM_FAT	RARM_FAT
Right arm lean mass	DRV_RARM_LEAN	RARM_LEAN - RARM_BMC
Right arm bone mass	WB_RARM_BMC	RARM_BMC
Trunk fat mass	WBC_TRUNK_FAT	TRUNK_FAT
Trunk lean mass	DRV_TRUNK_LEAN	TRUNK_LEAN - LRIB_BMC - RRIB_BMC - T_S_BMC - L_S_BMC - PELV_BMC
Trunk bone mass	DRV_TRUNK_BONE	LRIB_BMC + RRIB_BMC + T_S_BMC + L_S_BMC + PELV_BMC
Left leg fat mass	WBC_L_LEG_FAT	L_LEG_FAT
Left leg lean mass	DRV_L_LEG_LEAN	L_LEG_LEAN - LLEG_BMC
Left leg bone mass	WB_L_LEG_BMC	L_LEG_BMC
Right leg fat mass	WBC_R_LEG_FAT	R_LEG_FAT
Right leg lean mass	DRV_R_LEG_LEAN	R_LEG_LEAN - RLEG_BMC
Right leg bone mass	WB_RLEG_BMC	RLEG_BMC
Total fat mass	WBC_WBTOT_FAT	WBTOT_FAT
Total lean mass	OI_TOTAL_PURE_LEAN	TOTAL_PURE_LEAN
Total bone mass	WB_WBTOT_BMC	WBTOT_BMC
Android fat mass	AGC_ANDROID_FAT	ANDROID_FAT
Android lean mass	not available	not available
Android bone mass	not available	not available
Android fat free mass (lean & bone mass)	AGC_ANDROID_LEAN	ANDROID_LEAN
Gynoid fat mass	AGC_GYNOID_FAT	GYNOID_FAT

Description	Proposed Names	Hologic
Gynoid lean mass	not available	not available
Gynoid bone mass	not available	not available
Gynoid fat free mass (lean & bone mass)	AGC_GYNOID_LEAN	GYNOID_LEAN
VATcm^2	AGC_VFAT_AREA	VFAT_AREA
VATg	AGC_VFAT_MASS	VFAT_MASS
VATcm^3	AGC_VFAT_VOLUME	VFAT_VOLUME
SCATcm^2	AGC_SAT_AREA	SAT_AREA
SCATg	SAT_MASS	SAT_MASS
SCATcm^3	AGC_SAT_VOLUME	SAT_VOLUME

Table 4

T and Z Scores

Whole body T and Z scores are computed from BMD values identified by either WB_WBTOT_BMD or, where symmetry conditions apply, by SYM_WB_WBTOT_BMD. Calculations are performed in accordance with ISCD recommendations as of 2019 using the Hologic Apex Reference curve database.

Proposed Opal Variable	Description
WBTOT_BMD	total BMD of either QB_WBTOT_BMD or SYM_WB_WBTOT_BMD depending on symmetry conditions applied
WBTOT_T	T score
WBTOT_Z	Z score
WBTOT_PR	peak reference percent
WBTOT_AM	age matched percent

Table 5

Appendix

A.1 Apex MSSQL Server sql

```
select
p.IDENTIFIER1 as BARCODE,
CAST(s.SCAN_DATE AS date) as SCAN_DATE,
CAST(s.ANALYSIS_DATE AS date) as ANALYSIS_DATE,
CAST(ag.LAST_UPDATE AS date) as AG_LAST_UPDATE,
p.BIRTHDATE as DOB,
p.SEX as SEX,
p.WEIGHT as WEIGHT,
p.HEIGHT as HEIGHT,
p.ETHNICITY as ETHNICITY,
s.SERIAL_NUMBER,
case when s.SERIAL_NUMBER=87800 then 'UBC'
    when s.SERIAL_NUMBER=85968 then 'CAL'
    when s.SERIAL_NUMBER=86205 then 'DAL'
    when s.SERIAL_NUMBER=85921 then 'HAM'
    when s.SERIAL_NUMBER=86359 then 'MAN'
    when s.SERIAL_NUMBER=86036 then 'MCG'
    when s.SERIAL_NUMBER=86222 then 'MEM'
    when s.SERIAL_NUMBER=86147 then 'OTT'
    when s.SERIAL_NUMBER=86204 then 'SHR'
    when s.SERIAL_NUMBER=86155 then 'SFU'
    when s.SERIAL_NUMBER=86164 then 'VIC'
        else 'UNKNOWN' end as SITE_NAME,
```

s.SCANID as SCANID,

s.SCAN_MODE as SCAN_MODE,

w.WBTOT_AREA as WB_WBTOT_AREA,

w.WBTOT_BMC as WB_WBTOT_BMC,

w.WBTOT_BMD as WB_WBTOT_BMD,

w.SUBTOT_AREA as WB_SUBTOT_AREA,

w.SUBTOT_BMC as WB_SUBTOT_BMC,

w.SUBTOT_BMD as WB_SUBTOT_BMD,

w.HEAD_AREA as WB_HEAD_AREA,

w.HEAD_BMC as WB_HEAD_BMC,

w.HEAD_BMD as WB_HEAD_BMD,

w.LARM_AREA as WB_LARM_AREA,

w.LARM_BMC as WB_LARM_BMC,

w.LARM_BMD as WB_LARM_BMD,

w.RARM_AREA as WB_RARM_AREA,

w.RARM_BMC as WB_RARM_BMC,

w.RARM_BMD as WB_RARM_BMD,

w.LRIB_AREA as WB_LRIB_AREA,

w.LRIB_BMC as WB_LRIB_BMC,

w.LRIB_BMD as WB_LRIB_BMD,

w.RRIB_AREA as WB_RRIB_AREA,

w.RRIB_BMC as WB_RRIB_BMC,

w.RRIB_BMD as WB_RRIB_BMD,

w.T_S_AREA as WB_T_S_AREA,

w.T_S_BMC as WB_T_S_BMC,

w.T_S_BMD as WB_T_S_BMD,

w.L_S_AREA as WB_L_S_AREA,

w.L_S_BMC as WB_L_S_BMC,

w.L_S_BMD as WB_L_S_BMD,

w.PELV_AREA as WB_PELV_AREA,

w.PELV_BMC as WB_PELV_BMC,

w.PELV_BMD as WB_PELV_BMD,

w.LLEG_AREA as WB_LLEG_AREA,

w.LLEG_BMC as WB_LLEG_BMC,

w.LLEG_BMD as WB_LLEG_BMD,

w.RLEG_AREA as WB_RLEG_AREA,

w.RLEG_BMC as WB_RLEG_BMC,

w.RLEG_BMD as WB_RLEG_BMD,

w.PHYSICIAN_COMMENT as WB_PHYSICIAN_COMMENT,

wc.FAT_STD as WBC_FAT_STD,

wc.LEAN_STD as WBC_LEAN_STD,

wc.BRAIN_FAT as WBC_BRAIN_FAT,

wc.WATER_LBM as WBC_WATER_LBM,

wc.HEAD_FAT as WBC_HEAD_FAT,

wc.HEAD_LEAN as WBC_HEAD_LEAN,

wc.HEAD_MASS as WBC_HEAD_MASS,

wc.HEAD_PFAT as WBC_HEAD_PFAT,

wc.LARM_FAT as WBC_LARM_FAT,

wc.LARM_LEAN as WBC_LARM_LEAN,

wc.LARM_MASS as WBC_LARM_MASS,

wc.LARM_PFAT as WBC_LARM_PFAT,

wc.RARM_FAT as WBC_RARM_FAT,

wc.RARM_LEAN as WBC_RARM_LEAN,

wc.RARM_MASS as WBC_RARM_MASS,

wc.RARM_PFAT as WBC_RARM_PFAT,

wc.TRUNK_FAT as WBC_TRUNK_FAT,

wc.TRUNK_LEAN as WBC_TRUNK_LEAN,

wc.TRUNK_MASS as WBC_TRUNK_MASS,

wc.TRUNK_PFAT as WBC_TRUNK_PFAT,

wc.L_LEG_FAT as WBC_L_LEG_FAT,

wc.L_LEG_LEAN as WBC_L_LEG_LEAN,

wc.L_LEG_MASS as WBC_L_LEG_MASS,

wc.L_LEG_PFAT as WBC_L_LEG_PFAT,

wc.R_LEG_FAT as WBC_R_LEG_FAT,

wc.R_LEG_LEAN as WBC_R_LEG_LEAN,

wc.R_LEG_MASS as WBC_R_LEG_MASS,

wc.R_LEG_PFAT as WBC_R_LEG_PFAT,

wc.SUBTOT_FAT as WBC_SUBTOT_FAT,

wc.SUBTOT_LEAN as WBC_SUBTOT_LEAN,

wc.SUBTOT_MASS as WBC_SUBTOT_MASS,

wc.SUBTOT_PFAT as WBC_SUBTOT_PFAT,

wc.WBTOT_FAT as WBC_WBTOT_FAT,

wc.WBTOT_LEAN as WBC_WBTOT_LEAN,

wc.WBTOT_MASS as WBC_WBTOT_MASS,

wc.WBTOT_PFAT as WBC_WBTOT_PFAT,

wc.PHYSICIAN_COMMENT as WBC_PHYSICIAN_COMMENT,

oi.FAT_STD as OI_FAT_STD,

oi.LEAN_STD as OI_LEAN_STD,

oi.BRAIN_FAT as OI_BRAIN_FAT,

oi.WATER_LBM as OI_WATER_LBM,

oi.TOTAL_PERCENT_FAT as OI_TOTAL_PERCENT_FAT,

oi.BODY_MASS_INDEX as OI_BODY_MASS_INDEX,

oi.ANDROID_GYNOID_RATIO as OI_ANDROID_GYNOID_RATIO,

oi.ANDROID_PERCENT_FAT as OI_ANDROID_PERCENT_FAT,

oi.GYNOID_PERCENT_FAT as OI_GYNOID_PERCENT_FAT,

oi.FAT_MASS_RATIO as OI_FAT_MASS_RATIO,

oi.TRUNK_LIMB_FAT_MASS_RATIO as OI_TRUNK_LIMB_FAT_MASS_RATIO,

oi.FAT_MASS_HEIGHT_SQUARED as OI_FAT_MASS_HEIGHT_SQUARED,

oi.TOTAL_FAT_MASS as OI_TOTAL_FAT_MASS,

oi.LEAN_MASS_HEIGHT_SQUARED as OI_LEAN_MASS_HEIGHT_SQUARED,

oi.APPENDAGE_LEAN_MASS_HEIGHT_2 as OI_APPENDAGE_LEAN_MASS_HEIGHT_2,

oi.TOTAL_LEAN_MASS as OI_TOTAL_LEAN_MASS,

oi.PURE_LEAN_HEIGHT_SQUARED as OI_PURE_LEAN_HEIGHT_SQUARED,

oi.APPENDAGE_PURE_LEAN_HEIGHT_2 as OI_APPENDAGE_PURE_LEAN_HEIGHT_2,

oi.TOTAL_PURE_LEAN as OI_TOTAL_PURE_LEAN,

oi.PHYSICIAN_COMMENT as OI_PHYSICIAN_COMMENT,

ag.FAT_STD as AGC_FAT_STD,

ag.LEAN_STD as AGC_LEAN_STD,

ag.BRAIN_FAT as AGC_BRAIN_FAT,

ag.WATER_LBM as AGC_WATER_LBM,

ag.TISSUE_ANALYSIS_METHOD as AGC_TISSUE_ANALYSIS_METHOD,

ag.ROI_TYPE as AGC_ROI_TYPE,

ag.ROI_WIDTH as AGC_ROI_WIDTH,

ag.ROI_HEIGHT as AGC_ROI_HEIGHT,

ag.TOTAL_FAT as AGC_TOTAL_FAT,

ag.TOTAL_LEAN as AGC_TOTAL_LEAN,

ag.TOTAL_MASS as AGC_TOTAL_MASS,

ag.TOTAL_PFAT as AGC_TOTAL_PFAT,

ag.ANDROID_NAME as AGC_ANDROID_NAME,

ag.ANDROID_FAT as AGC_ANDROID_FAT,

ag.ANDROID_LEAN as AGC_ANDROID_LEAN,

ag.ANDROID_MASS as AGC_ANDROID_MASS,

ag.ANDROID_PFAT as AGC_ANDROID_PFAT,

ag.GYNOID_NAME as AGC_GYNOID_NAME,

ag.GYNOID_FAT as AGC_GYNOID_FAT,

ag.GYNOID_LEAN as AGC_GYNOID_LEAN,

ag.GYNOID_MASS as AGC_GYNOID_MASS,

ag.GYNOID_PFAT as AGC_GYNOID_PFAT,

ag.VFAT_BODY_NAME as AGC_VFAT_BODY_NAME,

ag.VFAT_BODY_FAT as AGC_VFAT_BODY_FAT,

ag.VFAT_BODY_LEAN as AGC_VFAT_BODY_LEAN,

ag.VFAT_BODY_MASS as AGC_VFAT_BODY_MASS,

ag.VFAT_BODY_PFAT as AGC_VFAT_BODY_PFAT,

ag.VFAT_OUTERWALL_NAME as AGC_VFAT_OUTERWALL_NAME,

ag.VFAT_OUTERWALL_FAT as AGC_VFAT_OUTERWALL_FAT,

```
ag.VFAT_OUTERWALL_LEAN as AGC_VFAT_OUTERWALL_LEAN,
ag.VFAT_OUTERWALL_MASS as AGC_VFAT_OUTERWALL_MASS,
ag.VFAT_OUTERWALL_PFAT as AGC_VFAT_OUTERWALL_PFAT,
ag.VFAT_CAVITY_NAME as AGC_VFAT_CAVITY_NAME,
ag.VFAT_CAVITY_FAT as AGC_VFAT_CAVITY_FAT,
ag.VFAT_CAVITY_LEAN as AGC_VFAT_CAVITY_LEAN,
ag.VFAT_CAVITY_MASS as AGC_VFAT_CAVITY_MASS,
ag.VFAT_CAVITY_PFAT as AGC_VFAT_CAVITY_PFAT,
ag.VFAT_AREA as AGC_VFAT_AREA,
ag.VFAT_MASS as AGC_VFAT_MASS,
ag.VFAT_VOLUME as AGC_VFAT_VOLUME,
ag.TAT_AREA as AGC_TAT_AREA,
ag.TAT_MASS as AGC_TAT_MASS,
ag.TAT_VOLUME as AGC_TAT_VOLUME,
ag.SAT_AREA as AGC_SAT_AREA,
ag.SAT_MASS as AGC_SAT_MASS,
ag.SAT_VOLUME as AGC_SAT_VOLUME,
ag.WAIST_CIRCUMFERENCE as AGC_WAIST_CIRCUMFERENCE,
ag.SUBCU_FAT_CORRECTION as AGC_SUBCU_FAT_CORRECTION,
ag.BODY_WIDTH as AGC_BODY_WIDTH,
ag.OUTER_WALL_WIDTH as AGC_OUTER_WALL_WIDTH,
ag.CAVITY_WIDTH as AGC_CAVITY_WIDTH,
ag.PHYSICIAN_COMMENT as AGC_PHYSICIAN_COMMENT
from PatScan.dbo.PATIENT p
join PatScan.dbo.ScanAnalysis s on s.PATIENT_KEY=p.PATIENT_KEY
```

```
join PatScan.dbo.Wbody w on w.PATIENT_KEY=s.PATIENT_KEY
and w.SCANID=s.SCANID
and w.SERIAL_NUMBER=s.SERIAL_NUMBER
left join PatScan.dbo.WbodyComposition wc on wc.PATIENT_KEY=s.PATIENT_KEY
and wc.SCANID=s.SCANID
and wc.SERIAL_NUMBER=s.SERIAL_NUMBER
left join PatScan.dbo.ObesityIndices oi on oi.PATIENT_KEY=s.PATIENT_KEY
and oi.SCANID=s.SCANID
and oi.SERIAL_NUMBER=s.SERIAL_NUMBER
left join PatScan.dbo.AndroidGynoidComposition ag on ag.PATIENT_KEY=s.PATIENT_KEY
and ag.SCANID=s.SCANID
and ag.SERIAL_NUMBER=s.SERIAL_NUMBER
where
p.IDENTIFIER1 not in ('1037')
order by p.IDENTIFIER1
```

A.2 Salix MySQL sql

```
select distinct concat('"',concat_ws('","',
d.id,
uid,
serial_number_id,
barcode,
h.name,
status,
pass,
ifnull(note,'NA'),
```

```
ifnull(summary,'NA'),
ifnull(u.name,'NA')
),"")
from
apex_deployment d
join apex_scan s on s.id=d.apex_scan_id
join apex_host h on h.id=d.apex_host_id
join scan_type t on t.id=s.scan_type_id
join apex_exam e on e.id=s.apex_exam_id
join apex_baseline b on b.id=e.apex_baseline_id
left join apex_deployment_code_summary m on d.id=m.apex_deployment_id
join serial_number n on n.id=e.serial_number_id
join live_cenozo.participant p on p.id=b.participant_id
join live_cenozo.site site on site.id=n.site_id
left join code c on d.id=c.apex_deployment_id
left join live_cenozo.user u on u.id=c.user_id
where invalid=0
and type='wbody'
and rank=1
and status in ('completed','exported')
order by uid
```