Calculating anthropometric measurement flags in CSPro

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Calculating z-scores within CSPro

CSPro logic supports the following mathematical operators:

Table 1: Mathematical operations supported by CSPro

Operations	Operands
Addition	+
Subtraction	-
Multiplication	*
Division	/
Modulo	%
Exponentiation	^

Using these operations, we can look into a way to flag weight and height measurements in CSPro. We are trying out an approach developed by Robert Johnston (rfjohnstonunicef@gmail.com)[1] from UNICEF that calculates the corresponding value for the anthropometric measurement being standardised at a specific standard deviation which in context of a flag would be set at the the upper and lower bounds used in the flagging criteria. The WHO flagging criteria are used. Below we show the formula used for these calculations.

[1] see https://github.com/RobertJohnston/SMART-Questionnaire

Calculate lower and upper height measurement given a child's age and sex that will produce a SD above and below +6 SD and -6 SD respectively

This is to calculate corresponding flags for height measurements given the age and sex of the child. The idea here will be that the height will be checked by calculating the height that would give an SD greater than +6 or lower than -6 using the child's age and sex.

The general formula is:

$$\begin{aligned} height_{\text{lower for boys}} &= 0.000000379386 \times age^5 - 0.000069515524 \times age^4 \\ &+ 0.004909805 \times age^3 - 0.168908042 \times age^2 \\ &+ 3.266127182 \times age + 39.95107423 \end{aligned}$$

$$\begin{aligned} height_{\text{upper for boys}} &= 0.000000477257 \times age^5 - 0.000080053304 \times age^4 \\ &+ 0.005071378 \times age^3 - 0.158048367 \times age^2 \\ &+ 3.584968875 \times age + 63.13173807 \end{aligned}$$

$$\begin{aligned} height_{\text{lower for girls}} &= 0.000000308918 \times age^5 - 0.000056212972 \times age^4 \\ &+ 0.003932757 \times age^3 - 0.135180355 \times age^2 \\ &+ 2.789665701 \times age + 39.23327346 \end{aligned}$$

$$\begin{aligned} height_{\text{upper for girls}} &= 0.000000371919 \times age^5 - 0.000065134503 \times age^4 \\ &+ 0.004358773 \times age^3 - 0.145396571 \times age^2 \\ &+ 3.553078292 \times age + 62.01230832 \end{aligned}$$

$$where:$$

$$\begin{aligned} age &= \text{age of child} \\ height_{\text{lower for boys}} &= \text{expected height for boys for a -6SD} \\ height_{\text{upper for boys}} &= \text{expected height for boys for a +6SD} \\ height_{\text{lower for girls}} &= \text{expected height for girls for a -6SD} \\ height_{\text{upper for girls}} &= \text{expected height for girls for a +6SD} \end{aligned}$$

In CSPro, these calculations can be approached similarly. In the following examples, we assume that the dataset captured in CSPro has the following variables:

Variables	Definitions
cage	Age of child in months
csex	Sex of child
height	Height of child

The possible steps/code in CSPro for creating logic for flagging HAZ can be:

```
// Declare variables
numeric aNumber;

// Create logic variables for each of the HAZ flags
numeric hazLowerBoys;
hazLowerBoys = 0.000000379386 * cage ^ 5 - 0.000069515524 * cage ^ 4
               + 0.004909805 * cage ^ 3 - 0.168908042 * cage ^ 2
               + 3.266127182 * cage + 39.95107423

numeric hazUpperBoys;
hazUpperBoys = 0.000000477257 * cage ^ 5 - 0.000080053304 * cage ^ 4
               + 0.005071378 * cage ^ 3 - 0.158048367 * cage ^ 2
               + 3.584968875 * cage + 63.13173807

numeric hazLowerGirls;
hazLowerGirls = 0.000000308918 * cage ^ 5 - 0.000056212972 * cage ^ 4
                + 0.003932757 * cage ^ 3 - 0.135180355 * cage ^ 2
                + 2.789665701 * cage + 39.23327346

numeric hazUpperGirls;
hazUpperGirs = 0.000000371919 * cage ^ 5 - 0.000065134503 * cage ^ 4
               + 0.004358773 * cage ^ 3 - 0.145396571 * cage ^ 2
               + 3.553078292 * cage + 62.01230832

// Add logic to flag height measurements - boys
if csex <> 1 and height > hazUpperBoys or height < hazLowerBoys then
  warning("Height measurement beyond expected value for child's age and sex",
          height)
          select("Repeat height measurement", height,
                 "Ignore warning", continue);
endif;
```

```
// Add logic to flag height measurements - girls
if csex <> 2 and height > hazUpperGirls or height < hazLowerGirls then
  warning("Height measurement beyond expected value for child's age and sex",
          height)
          select("Repeat height measurement", height,
                 "Ignore warning", continue);
endif;
```

Calculate lower and upper weight measurement given a child's age and sex that will produce a SD above and below +5 SD and -6 SD respectively

This is to calculate corresponding flags for weight measurements given the age and sex of the child. The idea here will be that the weight will be checked by calculating the weight that would give an SD greater than +5 or lower than -6 using the child's age and sex.

The general formula is:

$$\begin{aligned} weight_{\text{lower for boys}} &= 0.000000095420 \times age^5 - 0.00001662831 \times age^4 \\ &+ 0.001091416 \times age^3 - 0.033880085 \times age^2 \\ &+ 0.562601613 \times age + 1.139474257 \end{aligned}$$

$$\begin{aligned} weight_{\text{upper for boys}} &= 0.000000234816 \times age^5 - 0.000039531734 \times age^4 \\ &+ 0.002496579 \times age^3 - 0.072781678 \times age^2 \\ &+ 1.351053186 \times age + 6.972621013 \end{aligned}$$

$$\begin{aligned} weight_{\text{lower for girls}} &= 0.000000083218 \times age^5 - 0.000013843176 \times age^4 \\ &+ 0.000861019 \times age^3 - 0.025646557 \times age^2 \\ &+ 0.450277222 \times age + 1.111128346 \end{aligned}$$

$$\begin{aligned} weight_{\text{upper for girls}} &= 0.000000197736 \times age^5 - 0.000035478810 \times age^4 \\ &+ 0.002404164 \times age^3 - 0.074112047 \times age^2 \\ &+ 1.434496211 \times age + 6.482817802 \end{aligned}$$

$$where:$$

$$\begin{aligned} age &= \text{age of child} \\ weight_{\text{lower for boys}} &= \text{expected weight for boys for a -6SD} \\ weight_{\text{upper for boys}} &= \text{expected weight for boys for a +5SD} \\ weight_{\text{lower for girls}} &= \text{expected weight for girls for a -6SD} \\ weight_{\text{upper for girls}} &= \text{expected weight for girls for a +5SD} \end{aligned}$$

In CSPro, these calculations can be approached similarly. In the following examples, we assume that the dataset captured in CSPro has the following variables:

Variables	Definitions
cage	Age of child in months
csex	Sex of child
weight	Weight of child

The possible steps/code in CSPro for creating logic for flagging WAZ can be:

```
// Declare variables
numeric aNumber;

// Create logic variables for each of the WAZ flags
numeric wazLowerBoys;
wazLowerBoys = 0.000000095420 * cage ^ 5 - 0.00001662831 * cage ^ 4
               + 0.001091416 * cage ^ 3 - 0.033880085 * cage ^ 2
               + 0.562601613 * cage + 1.139474257

numeric wazUpperBoys;
wazUpperBoys = 0.000000234816 * age ^ 5 - 0.000039531734 * age ^ 4
               + 0.002496579 * age ^ 3 - 0.072781678 * age ^ 2
               + 1.351053186 * age + 6.972621013

numeric wazLowerGirls;
wazLowerGirls = 0.000000083218 * age ^ 5 - 0.000013843176 * age ^ 4
                + 0.000861019 * age ^ 3 - 0.025646557 * age ^ 2
                + 0.450277222 * age + 1.111128346

numeric wazUpperGirls;
wazUpperGirls = 0.000000197736 * age ^ 5 - 0.000035478810 * age ^ 4
               + 0.002404164 * age ^ 3 - 0.074112047 * age ^ 2
               + 1.434496211 * age + 6.482817802

// Add logic to flag weight measurements - boys
if csex <> 1 and weight > wazUpperBoys or weight < wazLowerBoys then
  warning("Weight measurement beyond expected value for child's age and sex",
          weight)
          select("Repeat weight measurement", weight,
                 "Ignore warning", continue);
endif;
```

```
// Add logic to flag weight measurements - girls
if csex <> 2 and weight > wazUpperGirls or weight < wazLowerGirls then
  warning("Weight measurement beyond expected value for child's age and sex",
          weight)
          select("Repeat weight measurement", weight,
                 "Ignore warning", continue);
endif;
```

Calculate lower and upper height measurement given a child's weight and sex that will produce a SD above and below +5 SD and -5 SD respectively

This is to calculate corresponding flags for height measurements given the weight and sex of the child. The idea here will be that the height will be checked by calculating the height that would give an SD greater than +5 or lower than -5 using the child's weight and sex.

The general formula is:

$$\begin{aligned} whz_{\text{lower for boys}} &= 0.002568778 \times weight^5 - 0.087078285 \times weight^4 \\ &+ 1.083870039 \times weight^3 - 6.017158294 \times weight^2 \\ &+ 20.69094143 \times weight + 24.23997191 \end{aligned}$$

$$\begin{aligned} whz_{\text{upper for boys}} &= 0.000039423 \times weight^5 - 0.003300406 \times weight^4 \\ &+ 0.100344392 \times weight^3 - 1.359686971 \times weight^2 \\ &+ 10.87955385 \times weight + 18.21716746 \end{aligned}$$

$$\begin{aligned} whz_{\text{lower for girls}} &= 0.001848563 \times weight^5 - 0.0606399 \times weight^4 \\ &+ 0.7185497 \times weight^3 - 3.7764632 \times weight^2 \\ &+ 15.4720170 \times weight + 28.0948931 \end{aligned}$$

$$\begin{aligned} whz_{\text{upper for girls}} &= 0.00002434 \times weight^5 - 0.00197858 \times weight^4 \\ &+ 0.05716011 \times weight^3 - 0.71815707 \times weight^2 \\ &+ 6.61322135 \times weight + 27.77925292 \end{aligned}$$

$$where:$$

$$\begin{aligned} weight &= \text{weight of child} \\ whz_{\text{lower for boys}} &= \text{expected height for boys for a -5SD} \\ whz_{\text{upper for boys}} &= \text{expected height for boys for a +5SD} \\ whz_{\text{lower for girls}} &= \text{expected height for girls for a -5SD} \\ whz_{\text{upper for girls}} &= \text{expected height for girls for a +5SD} \end{aligned}$$

In CSPro, these calculations can be approached similarly. In the following examples, we assume that the dataset captured in CSPro has the following variables:

Variables	Definitions
csex	Sex of child
weight	Weight of child
height	Height of child

The possible steps/code in CSPro for creating logic for flagging WHZ can be:

```
// Declare variables
numeric aNumber;

// Create logic variables for each of the WAZ flags
numeric whzLowerBoys;
whzLowerBoys = 0.002568778 * weight ^ 5 - 0.087078285 * weight ^ 4
               + 1.083870039 * weight ^ 3 - 6.017158294 * weight ^ 2
               + 20.69094143 * weight + 24.23997191

numeric whzUpperBoys;
whzUpperBoys = 0.000039423 * weight ^ 5 - 0.003300406 * weight ^ 4
               + 0.100344392 * weight ^ 3 - 1.359686971 * weight ^ 2
               + 10.87955385 * weight + 18.21716746

numeric whzLowerGirls;
whzLowerGirls = 0.001848563 * weight ^ 5 - 0.0606399 * weight ^ 4
                + 0.7185497 * weight ^ 3 - 3.7764632 * weight ^ 2
                + 15.4720170 * weight + 28.0948931

numeric whzUpperGirls;
whzUpperGirls = 0.00002434 * weight ^ 5 - 0.00197858 * weight ^ 4
                + 0.05716011 * weight ^ 3 - 0.71815707 * weight ^ 2
                + 6.61322135 * weight + 27.77925292

// Add logic to flag height measurements - boys
if csex <> 1 and height > whzUpperBoys or height < whzLowerBoys then
  warning("Height measurement beyond expected value for child's weight and sex",
          height)
          select("Repeat height measurement", height,
                 "Ignore warning", continue);
endif;
```

```
// Add logic to flag height measurements - girls
if csex <> 2 and height > whzUpperGirls or height < whzLowerGirls then
  warning("Height measurement beyond expected value for child's age and sex",
          height)
          select("Repeat height measurement", height,
                 "Ignore warning", continue);
endif;
```

Determining SAM children by WHZ

This approach can also be used to identify children as SAM by WHZ by calculating height of child given weight that will give an SD of -3.

The general formula is:

$$\begin{aligned} whz_{\text{-3SD boys}} &= 0.000995821 \times weight^5 - 0.041179737 \times weight^4 \\ &+ 0.622839074 \times weight^3 - 4.192765025 \times weight^2 \\ &+ 17.49551065 \times weight + 23.63868321 \end{aligned}$$

$$\begin{aligned} whz_{\text{-3SD for girls}} &= 0.000754341 \times weight^5 - 0.0299748 \times weight^4 \\ &+ 0.4284523 \times weight^3 - 2.7036671 \times weight^2 \\ &+ 13.0452680 \times weight + 27.9253576 \end{aligned}$$

$$where:$$

$$\begin{aligned} weight &= \text{weight of child} \\ whz_{\text{-3SD boys}} &= \text{expected height for boys for a -3SD} \\ whz_{\text{-3SD girls}} &= \text{expected height for girls for a -3SD} \end{aligned}$$