Amsterdam Public Health

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Quantitative research - Research instruments - Physical measurement instruments	Set-up & Conduct- Methods & Data Collection	
	VERSION	

Aim
To ensure that reliable physical measurement instruments are used.

Requirements
Use a measurement protocol and logbook per physical measurement instrument;
Perform regular calibrations of the physical measurement instruments.

Documentation
- A clear measurement protocol and logbook;
- Results of the calibrations.

Responsibilities
Executing researcher:
- To determine the measurement error of the instruments;
- To regularly calibrate the instruments that are used and review how well the instruments work;
- To monitor whether the instrument fulfills accuracy requirements;
- To check whether the measurement protocol fulfills the quality assurance requirements;
- To create and maintain a measurement protocol and logbook;
- To instruct research assistants how to use the instruments, by handing them a clear measurement protocol.

Project leaders:
- To ensure that the executing researcher determines and documents the level of measurement accuracy and the maximum, acceptable level of the measurement error according to the measurement protocol.

Research assistant:
- To maintain a measurement protocol and logbook while using the measurement instrument.

How to
Physical measurement instruments are often used to determine physical characteristics in epidemiological research, such as height, weight, blood pressure, exercise capacity, lung volume, etc. For each characteristic, there are a number of instruments which you can choose from.
In short, the following steps should be taken for determining which instrument suits your research best:

1. Determining the following for each physical measurement instrument:
Accuracy (precision)
- Precision is related to the desired unit in which you want to measure, e.g., grams or kilograms, decimals, etc. See for more information about this topic the guideline 'Data provided by third parties' in this Quality Handbook.

Range of instrument
- Determine the range in which the measurement instrument needs to be accurate.

Measurement error

- It is very important to think about what level of measurement error is acceptable for your instrument. Decide what the minimal (clinically) important change (MIC) is you wish to measure with the instrument. The measurement error always needs to be smaller than this MIC. In many cases you will have to determine the measurement error of the instrument yourself. See for more information about this topic the paragraph on calibration in this guideline and the guideline 'Evaluating measurement instruments'.

2. Choice of instrument:
Taken into account your desired level of precision, measurement range and measurement error, you can determine which manufacturer provides the instrument that fulfills your requirements best. When making this decision, it is recommended to consider the following questions:

- How much does the instrument cost and what are the costs associated with use and maintenance?
- Is the equipment easy to use?
- How reliable is the instrument?
- Could you borrow the instrument from colleagues or others that work on a similar project?
- Do others have (good) experience(s) using this instrument?

3. Calibration:
Before using an instrument, it needs to be calibrated to ensure it is doing what it should be doing. Most manufacturers describe the calibration process in a manual. To give you an idea of such a manual we provide an example for calibrating scales: (1) take a number of measurements with standard weights; (2) choose measurement points at the bottom, middle and top of the measurement range, e.g., 0, 10, 20 and 30 kilograms. Determine whether the values measured fall within the range you have set. Plot the values measured against the measurement points (in this example: 0, 10, 20, 30). This should deliver a large correlation. The instrument is now calibrated. Some cases will require more than a simple calibration procedure such as this. For instance, in situations where a complex and expensive instrument is being replaced by a simpler and/or cheaper one. A validation study will need to be conducted to determine whether the new instrument is equally valid, accurate and reliable as the old instrument in a group of similar individuals. The Bland-Altman method can be used for this purpose [1].

4. Measurement error and intra- and inter-observer reliability:
To determine measurement error of an instrument,. The measurement error can be determined with the Bland-Altman method or expressed using the Standard Error of Measurement (SEM). See for more information about this topic the guideline 'Evaluating measurement instruments'. The guideline 'Recruiting and training data collectors' can also be consulted.

5. Monitoring:
It is recommended to check whether the instrument is still working properly before performing measurements. For a set of scales: choose a standard (an object with a known/set weight) and check whether the scales reflect the right weight. A tape measure, skinfold calipers, or other measures can be regularly checked by measuring a fixed object in the same way. Record the date, instrument and measurement value in the logbook.

6. Annotations:

The calibration mode and method should be noted in the logbook. This is also the case for maintenance. It is recommended to fully calibrate the equipment after each maintenance session and before using it again. Determining the measurement error and/or intra- or inter-observer reliability of a new existing measurement instrument is often worth the effort. You can publish it as a separate article. For consultation about this topic, you can email to cosmin@vumc.nl

7. Measurement(s):
Use a measurement protocol that exactly describes how the measurements are performed and ensure that everybody does this in the same way. See for more information about this topic the guideline 'Recruiting and training data collectors'.
The following issues should also be considered:

1. On which part(s) of the body are the measurements going to be carried, and how are this/these position(s) determined?
2. Describe the standard measurement process;
3. How frequently are measurements repeated?
4. How can you read the instrument most accurately?
5. Are there environmental factors that influence the measurement? If this is the case, then standardize the contextual conditions as much as possible and record the contextual conditions present during the measurement. For example, you may need to record the time of the day, the level of humidity and the room temperature during an exercise measurement;
6. If you are expecting very small differences, you could also explore how environmental factors influence your measurements and correct for these as much as possible;
7. Write down instructions for the participants;
8. If it is possible, you could provide a practice session for participants;
9. How should you check the instruments functioning?
10. What is the appropriate calibration method?;
11. Record things such as who is performing the measurement and which instrument is being used.

8. Finally:
A specific check, calibration method and validation of the measurement protocol are required for each type of instrument. Use your common sense and ask colleagues or the supplier how these issues should be approached.

References
[1] Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. Lancet, 1986, 307-10.

Audit questions

- Have the desired accuracy, measurement range and error been determined?
- Has the right instrument been used?
- Does the instrument satisfy the criteria applied?
- Has the instrument been calibrated and has its functioning been regularly checked?
- Has this been clearly recorded?
- Is there a clear measurement protocol?
- Are logbooks kept up to date?
- Has the inter- or intra-reliability been determined?

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LINKS

	Link

DOCUMENT HISTORY

Version	Status	Date	Name
4.0	Revision	10FEB2021	Dr. Erik Timmermans, Dr. Wieneke Mokkink
3.0	Revision guideline	16DEC2016	EMGO
2.0	Revision format	12MAY2015	EMGO
1.2	References to guideline 1.1B-08 replaced by the updated guidelines	30JAN2011	EMGO
1.1	Translation into English	01JAN2010	EMGO

DOCUMENT APPROVAL

Role	Name	Date
Project Leader	Dr. Seta Jahfari	13MAY2021