Title:

Within and between-rater reproducibility and validity of a novel portable laser height meter

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Author contributions:

GS, MGJ and SA designed the study. GS developed the portable laser distance metre. GS is the guarantor of the study and wrote the draft for the protocol with help from all authors. GS, JRI and MBD will perform data collection. GS will perform statistical analyses and write the draft for the manuscript of the paper. JR, TM, JRI, MBD, and SA will assist in interpretation of results, read, provide feedback and approve the final manuscript of the paper.

Sponsor contact information

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Background:

Height may be used to calculate body mass index [1] and reference interval for normal lung function [2], together with serving as an indicator for possible vertebral fractures in osteoporosis [3] and growth retardation in children [4]. Height is typically measured using the "gold standard" a fixed stadiometer in a clinical setting [2,5]. However, newer studies have investigated alternative ways of measuring height using portable measuring devices with laser distance metres [6,7]. The advantage with this type of measure is the ability to potentially perform reliable measure in settings outside clinical controlled settings. Recently researchers [6] developed a measuring device which required adjustments of measuring axes by hand, which resulted in a measurement error of 0.35 cm compared with 0.20-0.30 cm in fixed stadiometers [5]. In order to optimise this, the author's suggested that future measuring devices using laser distance meters should be fixed in one or more measurement axes. Thus, we have developed a portable height device (PHD), which is fixated in two axes using a laser distance metre.

Objectives:

Primary objective:

To investigate inter– and intra-rater reproducibility of the PHD

Secondary objectives:

To assess agreement between the PHD and wall-fixed digital stadiometer.

Methods:

Participants:

We expect to enrol approximately 30 adults, 18+ years old men and women in the study. Participants will be recruited through convenience sampling in order to maximise recruitment efforts during the time of the study. We will collect data on gender, age, and height.

Ethics:

Written informed consent will be obtained from all participants prior to the study. The local ethics committee will be consulted for approval of the study. Approval will also be obtained from the Danish Data Protection Agency.

Measuring devices:

Portable laser measuring device:

A laser distance meter (Bosch Zamo, Robert Bosch GmbH, Gerlingen-Schillerhöhe, Germany) will be mounted perpendicularly to the end of a wooden lath (3x4x50 cm) (see Figure 1). The other end of the lath will be mounted perpendicular to a T-shaped metal plate which will fixate the x- and z-axis of the laser measuring device. The PHD will measure vertically down in its z-axis from the participant's vertex to the floor in front of the participant.

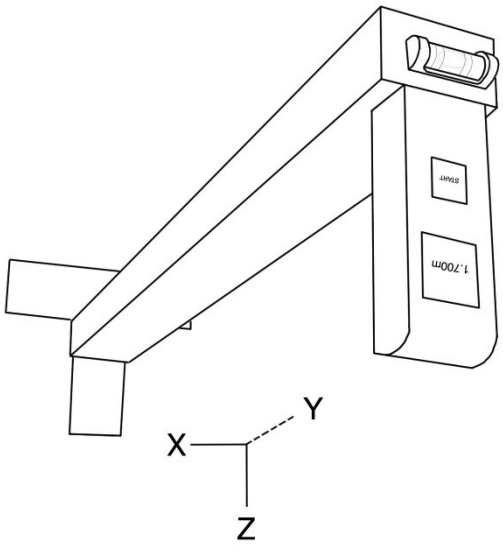

Figure 1

Stadiometer (reference standard):

We will use a fixed stadiometer as a reference (Harpenden Stadiometer, Holtain Limited, Crosswell, UK).

Procedure:

Measurements will be performed at Aalborg University Hospital, Aalborg, Denmark. Two raters will independently perform height measurements in two separate rooms with each measuring device (PHD and fixed stadiometer) on all participants. Each rater will perform three measures per device. During measurements, participants will be asked to stand flat on the floor (hard surface) without shoes. Furthermore, participants will be asked to stand with their heels positioned together and against the wall

during both type of measurements. Each rater will make sure that participants' heads are be positioned in the Frankfurt plane, and encourage participants to stand with a straight back against the wall.

Stadiometer (reference standard):

The measuring device will be pulled down to the skull. Afterwards, the participant will be asked to take a deep breath and hold it, after which the measurement will be performed.

Portable laser measuring device:

The lath with the laser distance meter will be placed on top of the participant's vertex and fixated in two axes by holding the T-shaped piece against the wall (See Figure 2). The lath will be rotated until the laser distance meter points vertically, which is done using a bubble level mounted on the end of the lath. The laser distance meter will be activated by clicking on the "START" button. Participants are asked to take a deep breath and hold it, after which the measurement will be locked and recorded. Following each measurement, the participant will take a step away from the measuring area and afterwards step back again to replicate the measurement procedure.

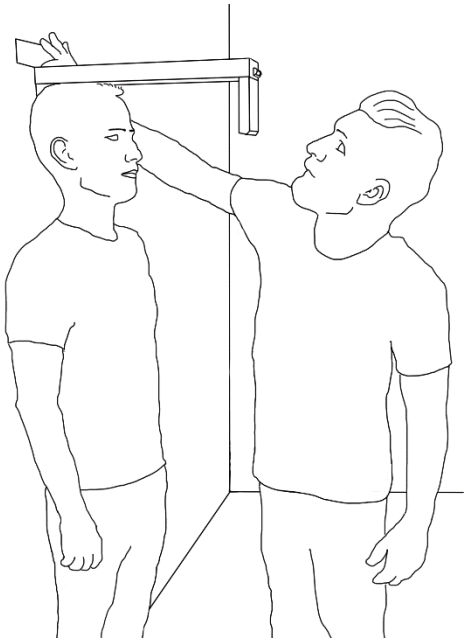

Figure 2

Blinding:

The blinding process is illustrated in Figure 3. All 30 participants will be measured using the laser distance meter first by each rater. When this stage is complete, measurements will be secured and inaccessible, in order to blind the raters when performing stadiometer measurements afterwards. We will assume that each rater will not be able to remember each participants' height when 30 participants are measured consecutively. After the stadiometer measurements have been performed, data will also be secured and inaccessible. Afterwards, this entire procedure will be repeated once more. Measurements will be collected using a data capturing tool (REDCap) [8].

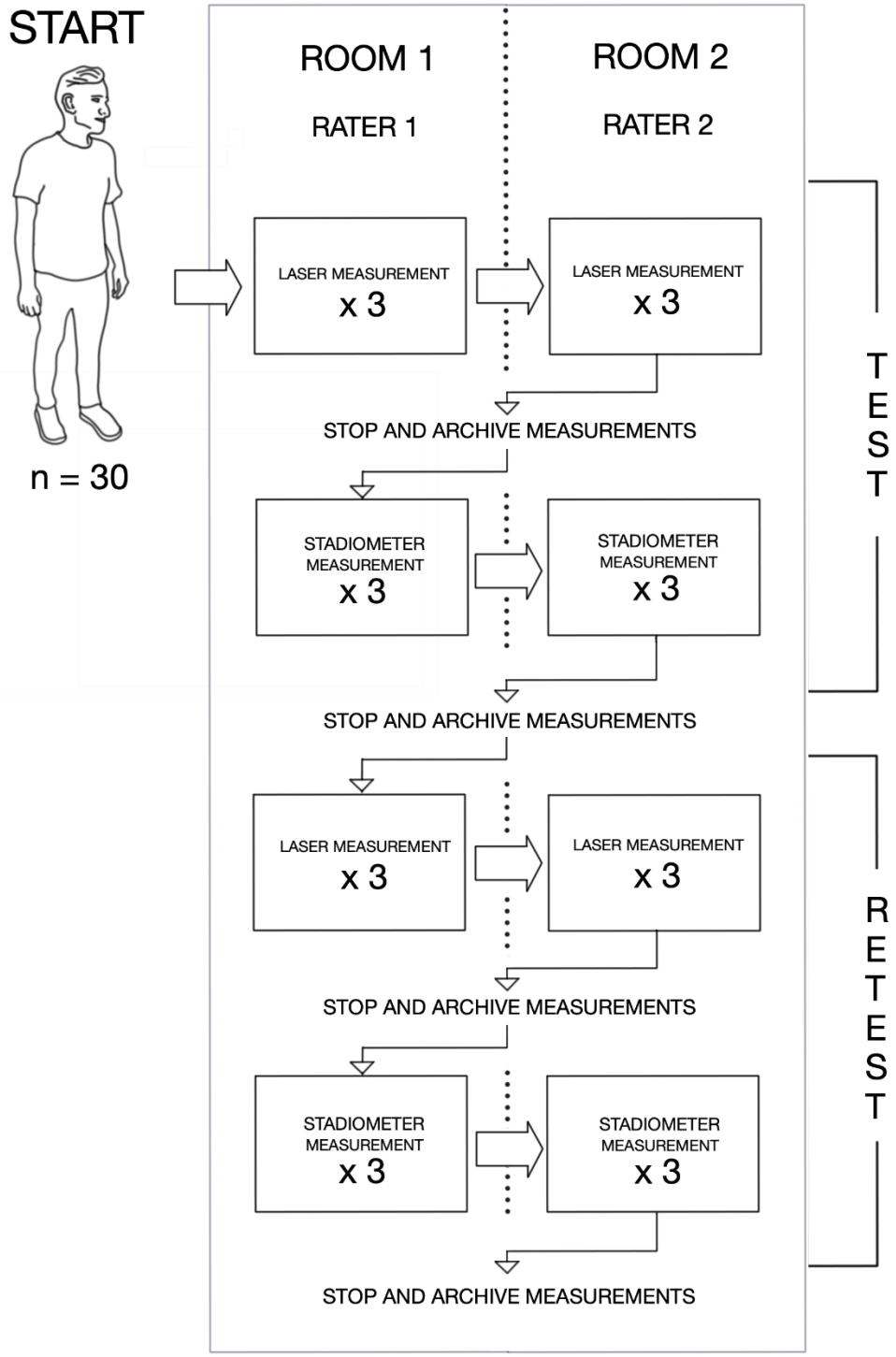
START
n = 30
ROOM 1
RATER 1
ROOM 2
RATER 2
LASER MEASUREMENT
x 3
LASER MEASUREMENT
x 3
STOP AND ARCHIVE MEASUREMENTS
STADIOMETER MEASUREMENT
x 3
STADIOMETER MEASUREMENT
x 3
STOP AND ARCHIVE MEASUREMENTS
TEST
LASER MEASUREMENT
x 3
LASER MEASUREMENT
x 3
STOP AND ARCHIVE MEASUREMENTS
STADIOMETER MEASUREMENT
x 3
STADIOMETER MEASUREMENT
x 3
STOP AND ARCHIVE MEASUREMENTS
RETEST

Figure 3

Statistics:

Participants:

Age will be reported in mean with standard deviations, and gender will be reported in proportions. Both height measures will have 95% confidence intervals reported.

Agreement:

Mean of all three measurements per rater per measuring device per participants will be calculated. The difference between the means will be calculated by subtracting the mean laser measurement from the mean stadiometer measurement. This will also be performed with only the mean of the two first measurements, and finally also the first measurement. Thus, we would be able to evaluate whether one measurement would have similar agreement with two or three measurements. We will generate Bland Altman plots with limits of agreement (LOA) together with standard error of measurements (SEM) and coefficient of variation (c.v) for all the above-mentioned combinations.

Reliability:

We will calculate Intraclass Correlation Coefficients (ICC) with 95% confidence intervals between measuring devices.

Software:

Statistics will be performed using Microsoft Excel for Mac version 16.28 (Microsoft Office, Microsoft Corporation, WA) and IBM SPSS Statistics for MacOS version 25.0 (IBM Corporation, Armonk, NY).

Conflicts of interest:

The authors report no conflicts of interest.

Dissemination:

We plan to publish in an English-language journal. The reporting of the study will follow the current guidelines for reliability and agreement studies (GRRAS) [9].

References:

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