Microrint pulmonary function testing in older adults with an intellectual disability

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Summary

Background: Pulmonary function testing is not feasible in many adults with intellectual disabilities, because of difficulties with understanding and cooperation.

Aims: To investigate feasibility, repeatability and reproducibility of measuring airway resistance using the interrupter technique (MicroRint) in people aged 50 years or over with a mild, moderate or severe intellectual disability.

Method: Sixty-seven participants were recruited through three Dutch care centres. Feasibility (percentage adequate first measurements) as well as repeatability and reproducibility were evaluated using the Intraclass Correlation Coefficient (ICC) and the within subject variation (SDw).

Results: The group with a severe intellectual disability was too small for valid analyses and was therefore excluded. Feasibility: in 86.6% of the total study group, 88.2% of the participants with a mild and 89.7% of the people with moderate intellectual disability, the first measurement was successful. Repeatability: In the total study group, the group with a mild and the group with a moderate intellectual disability the ICC values were 0.76, 0.84 and 0.71, respectively, SDw values were 0.11 kPa/l/s, 0.10 kPa/l/s, 0.10 kPa/l/s, respectively. Reproducibility: In the total study group, the group with a mild and the group with a moderate intellectual disability the ICC values were 0.72, 0.67 and 0.72, respectively, SDw values were 0.14 kPa/l/s, 0.15 kPa/l/s, 0.11 kPa/l/s, respectively.

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Conclusion: Feasibility, repeatability and reproducibility of measuring airway resistance using the MicroRint are good and acceptable in people with a mild or moderate intellectual disability aged 50 years or over.

Background

Although no studies have been published on the prevalence or incidence of pulmonary disease in people with an intellectual disability, in clinical practice, pulmonary disease is a common disorder in this group.

Because in our clinical experience, spirometry is not feasible in most people with an intellectual disability, the diagnosis is usually based on observable symptoms. As a result, mild and moderate pulmonary problems may be missed and under treatment is to be expected, whereas over treatment is also possible because of the lack of objective monitoring of effects. An alternative to spirometry could be the measurement of airway resistance during tidal breathing. Airway resistance has a good correlation with the Forced Expiratory Volume in one second, FEV_1, which is measured with spirometry.[1]

The MicroRint is a portable device that measures airway resistance using the interrupter technique. The measurement is performed during tidal breathing and needs a minimum of cooperation and comprehension of the patient. Earlier research already has shown that measuring airway resistance using the MicroRint is feasible and reproducible in children and adults in the normal population.[2,3] Carter et al.[1] have reported a good correlation of MicroRint outcome with the FEV_1 (Forced Expiratory Volume in 1 s.) obtained by spirometry. In addition, one previous study has evaluated the interrupter technique in children with severe generalized cerebral palsy. Veugelers et al.[4] showed in this study that measuring airway resistance is a feasible and reproducible method, and can also be used to measure reversibility in these children. The feasibility and outcome of airway resistance measurements have not been studied previously in adults with an intellectual disability.

Therefore we investigated the feasibility, repeatability and reproducibility of measuring airway resistance using the interrupter technique in people with an intellectual disability aged 50 years or over.

Methods

Study population

This diagnostic study was performed in three care centres for people with an intellectual disability (ID) in the Netherlands: Amarant in Tilburg, Lunetzorg in Eindhoven and Steinmetz | de Compaan in Den Haag.

Regardless of any past or present pulmonary condition, all clients with a mild, moderate or severe intellectual disability, aged 50 years and over in 2008, were eligible for inclusion. Primary medical care was provided by general physicians or intellectual disability physicians. The level of intellectual disability had been determined by qualified psychologists. Participants who had dementia or both a severe motor and an intellectual disability were excluded, because this would make the group more heterogeneous.

With an expected Intraclass Correlation Coefficient (ICC) for repeatability and reproducibility between 0.8 and 0.9, a power of 0.80 and a significance level of 0.05, a minimum of 29 successful measurements per intellectual disability level (mild, moderate, severe) were needed to calculate a valid reproducibility.

Taking into account an expected consent rate of approximately 60%, 127 clients, who were randomly selected, were invited to participate, in order to obtain a representative study population.

Prior to the study, ethical consent was obtained from the medical ethics committee of the Erasmus University Medical Center in Rotterdam (MEC-2008-010). Informed consent was asked from the participants and/or their legal representatives.

MicroRint and measurement procedure

The MicroRint (MicroMedical Ltd, Rochester, UK), a portable device for measurement of airway resistance, was used.

A recording involves an occlusion of the shutter within the device during the expiration phase of tidal breathing. During this occlusion the pressure at the airway opening equilibrates with the alveolar pressure within a few milliseconds. Pressure directly after the interruption is calculated by measuring the pressure at 30 ms and 70 ms after the closure of the valve and linearly back extrapolated to $t = 0$ ms (Fig. 1). Rint (kPa/l/s) is calculated as the ratio between this pressure change (kPa), and the pre-interruption flow (l/s). To improve validity, the outcome median value (mRint) is based on a minimum of 5 and a maximum of 15 interpretable Rint values per measurement. Therefore, all measurements consisted of 15 successfully recorded interruptions.

All measurements were performed by one of the investigators, at the home of the participant. Before the measurement started the sound of the occlusion was demonstrated and the participant was able to get familiar with the facemask. Three types of fitting non-compliant facemasks were used, covering the nose and mouth. Facemasks were used, because it was expected that the participants in general were unable to close their lips intentionally around a mouth piece resulting in air leakage. The measurements were performed while the participant was seated in an upright position. The researcher stood behind the participant to make sure the facemask was put correctly around mouth and nose. The cheeks were supported to diminish resonance.[5] If necessary, one of the caregivers was present to support and reassure the participant. If the
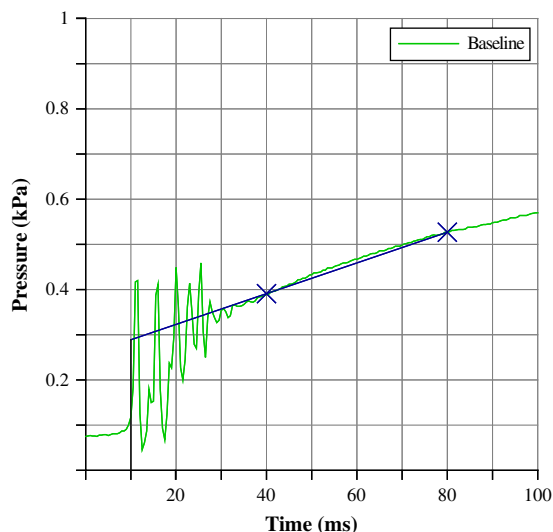
Figure 1   Example of a pressure—time curve.

participant did not tolerate the recording, the measurement was paused or stopped immediately.

There were two separate measurement days per participant. At day one three measurements (each consisting of 15 interruptions) were carried out with an interval of 5—10 min (repeatability). Day two was 1—2 weeks after the first measurement day. One measurement was carried out that day (reproducibility).

If a participant used pulmonary medication, the time between intake and measurement had to be the same at both measurement days.

Analysis

The measurement data from the MicroRint were imported into the program Rida (MicroMedical ltd, Rintbase 5 version 1.21 for Windows 2002). Although MicroRint automatically excludes pressure and flow curves that have major deviations, the researchers also judged the curves by inspection (''eyeballing''), based on previously published criteria
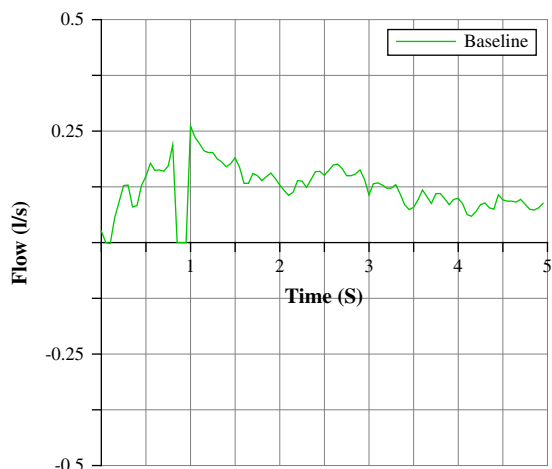

Figure 2   Example of a flow—time curve.

developed by Veugelers et al.[6] Each pressure and flow curve (Figs. 1 and 2) was separately assessed by two investigators. If there was no consensus a third researcher made the final decision to accept or reject the curves. A measurement was considered successful, if for at least 5/15 interruptions the pressure and flow curve had been accepted. The median Rint value (mRint) of these valid interruptions per measurement was calculated,[7] thus resulting in 3 separate mRint values on day one and one value on day two.

Feasibility

The following aspects were distinguished: number of participants with a successful first measurement and number of participants with four successful recordings. We considered the MicroRint a feasible method for measuring airway resistance in this population, if the first measurement (day 1) was successful in more than 66% of the participants. Using the binominal test, p-values were calculated to establish whether the calculated feasibility was either or not based on coincidence ($p < 0.05$). In addition, a 95% confidence interval was calculated for feasibility values.

Reproducibility

For repeatability the three mRint values produced at the first measurement day were compared using the Intraclass Correlation Coefficient (ICC), and the within subject variation (SDw). The ICC compares the variability within a participant with the variability between participants. It is calculated by dividing the between subject variation by the total variation. The SDw is an indicator of the variation within a participant and is calculated by the square root of the within-subject variation. A low SDw value corresponds with less variation. A low SDw would allow the use of the MicroRint for follow-up purposes. These two measures have been used in earlier research on the reproducibility of MicroRint in children.[4,8—11] An ICC of >0.60 was considered acceptable and an ICC >0.80 was considered good.[4,9—11] For reproducibility the average mRint value was calculated for participants who performed one, two or three successful first measurements on day one. These were compared with the outcome of the second measurement day. For the analysis again the ICC and SDw were used. Blant—Altman plots were made in order to visualize repeatability and reproducibility. These plots show the difference in Rint value (kPa/L/s) between two measurements against the mean Rint value (kPa/L/s) of those two measurements.

All data were analysed by means of the statistics programs SPSS (version 14.0 for Windows) and SAS (SAS institute Inc, SAS version 8.2 for windows), both for the total study group and per level of intellectual disability (mild, moderate, severe).

Results

Sixty-seven out of 127 approached participants consented to participate (52.8%).

The characteristics of the study group are shown in Table 1. The group with a severe intellectual disability was

Table 1 Characteristics of the participants.

	Total group	Mild ID	Moderate ID	Severe ID
Approached for informed consent, n	127	62	55	10
Informed consent, n (%)	67 (52.8%)	34 (54.8%)	29 (52.7%)	4 (40.0%)
Age (years), mean ± SD	62.6 ± 8.4	63.8 ± 8.7	60.7 ± 8.0	66.5 ± 8.6
Gender				
Male, n (%)	45 (67.2%)	23 (67.6%)	19 (65.5%)	3 (75%)
Female, n (%)	22 (32.8%)	11 (32.4%)	10 (34.5%)	1 (25%)

ID = intellectual disability.

Table 2 Feasibility: number of participants with successful measurements.

	N	First measurement on day 1 n (%), (95% CI)	All 4 measurements n (%), (95% CI)
Total cohort	67	58 (86.6%)* (76.0—93.7)	48 (71.6%) (59.3—82.0)
Mild ID	34	30 (88.2%)* (72.5—96.7)	22 (64.7%) (46.5—80.3)
Moderate ID	29	26 (89.7%)* (72.6—97.8)	23 (79.3%) (60.3—92.0)
Severe ID	4	2 (50.0%)	2 (50.0%)

* $p < 0.05$.
ID = intellectual disability.
CI = confidence interval.

too small to calculate feasibility, repeatability and reproducibility.

Feasibility

The numbers of successful first measurements of the total group and per intellectual level are shown in Table 2. In both the mild and moderate intellectual disability group the calculated feasibility is above 66%. In two out of four participants with severe intellectual disability a successful first measurement was performed.

Reproducibility

As an indication of the outcomes, the average median Rint values (a-mRint) per level of intellectual disability per measurement are shown in Table 3. Outcomes of repeatability and reproducibility are shown in Figs. 3 and 4, respectively and in Table 4.

Discussion

This is the first study to measure airway resistance using the interrupter technique in a large group of older adults with

an intellectual disability. It shows that measuring airway resistance using the MicroRint is feasible, repeatable and reproducible in elderly people with a mild or moderate intellectual disability.

In both the groups with mild and moderate intellectual disability, feasibility was over 85%, which we consider a very favorable result.

Because no studies evaluating the reproducibility of airway resistance measurements were found in adults with an intellectual disability we compared the results in this study with studies in children. Intraclass Correlation Coefficient (ICC) values we found are slightly lower than values in healthy children,[9,11] but higher than correlations in children with severe generalized cerebral palsy.[4]

Child et al.[10] found comparable ICC values for repeatability in 50 healthy children. The within subject variation (SDw) is comparable to values in healthy children (Table 5).[8]

Some factors may have influenced the results in this study. First of all the applied consent procedure might have introduced some form of selection bias, because 46.1% of the legal representatives and/or the participants themselves did not consent to participate. The reason for no consent was not retrieved. It is possible that these participants did not participate in the research because of

Table 3 The average median Rint values (a-mRint) per measurement and per level of intellectual disability.

	a-mRint (kPa/l/s) mean ± SD measurement 1	a-mRint (kPa/l/s) mean ± SD measurement 2	a-mRint (kPa/l/s) mean ± SD measurement 3	a-mRint (kPa/l/s) mean ± SD measurement 4
Total study group	0.50 ± 0.24	0.48 ± 0.23	0.48 ± 0.21	0.53 ± 0.30
Mild ID	0.46 ± 0.23	0.42 ± 0.25	0.42 ± 0.25	0.48 ± 0.29
Moderate ID	0.51 ± 0.21	0.52 ± 0.19	0.53 ± 0.16	0.54 ± 0.23

ID = intellectual disability.
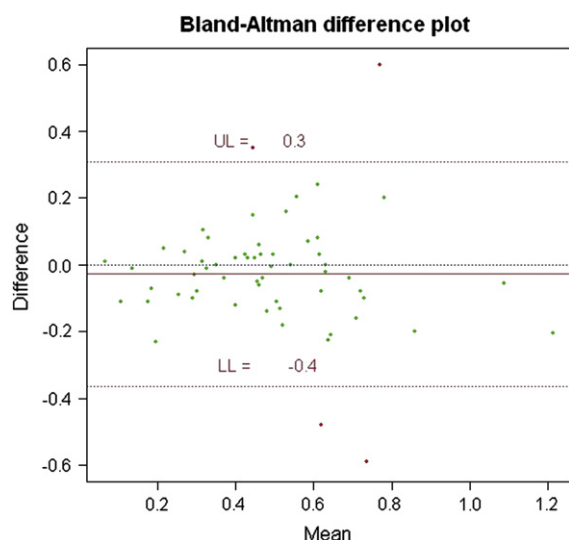CI = confidence interval.

Bland-Altman difference plot

Figure 3 Bland—Atman difference plot for the repeatability. It shows the difference in Rint value (kPa/L/s) between measurement one and two on day one against the mean Rint value (kPa/L/s) of those two measurements. Straight red line = mean Rint; dotted red line UL = upper limit (+2SD); dotted red line LL = lower limit (−2SD). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

expected behavioral problems. This may have had a positive effect on the feasibility.

Second, the power calculation had resulted in 29 adequate measurements per intellectual disability level to
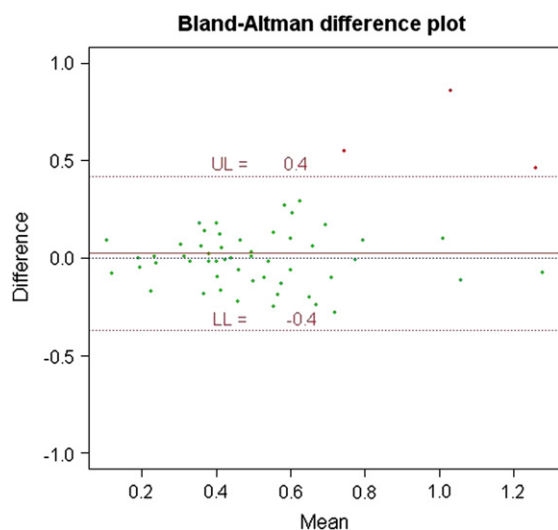
Table 4 Repeatability and reproducibility.

	ICC	SDw (kPa/l/s)
Repeatability		
Total study group	0.76	0.11
Mild ID	0.84	0.10
Moderate ID	0.71	0.10
Reproducibility		
Total study group	0.72	0.14
Mild ID	0.67	0.15
Moderate ID	0.72	0.11

ID = intellectual disability.
ICC = intraclass correlation coefficient.
SDw = within subject variation.

calculate a valid reproducibility. In the group with a mild intellectual disability this number was reached. The ICC in this group was higher than 0.8 and is considered good. However the group size of people with a moderate intellectual disability was lower (four test persons short). The ICC in this group was lower than 0.8 but higher than 0.6 and is considered acceptable. It is possible that if the group size of people with a moderate intellectual disability was higher that this would have had a positive result on the ICC.

Finally, the study population was to some extent heterogeneous. Participants with and without pulmonary disease, with and without pulmonary medication, smokers and non-smokers were included. This might also have had its effect on the ICC. If the studied population had been more homogeneous, the variation between participants might have been lower, resulting in higher ICC values.

Bland-Altman difference plot

Figure 4 Bland—Atman difference plot for the reproducibility. It shows the difference in Rint value (kPa/L/s) between measurement one on day one and measurement four on day two against the mean Rint value (kPa/L/s) of those two measurements. Straight red line = mean Rint; dotted red line UL = upper limit (+2SD); dotted red line LL = lower limit (−2SD). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 5 Repeatability and reproducibility compared to other studies in children.

	ICC	SDw(kPa/l/s)
Repeatability		
This study:		
Total study group	0.76	0.11
Mild ID	0.84	0.10
Moderate ID	0.71	0.10
Chan et al. '03[a]	0.97	
Child et al. '01[a]	0.77	
Lombardi et al. '01[a]	0.87	
Veugelers '06[b]	0.58	0.13
Beelen et al. '03[a]		0.10
Reproducibility		
This study:		
Total study group	0.72	0.14
Mild ID	0.67	0.15
Moderate ID	0.72	0.11
Chan et al. '03[a]	0.75	
Lombardi et al. '01[a]	0.91	
Veugelers '06[b]	0.56	0.14
Beelen et al. '03[a]		0.13

ICC = Intraclass Correlation Coefficient.
SDw = within subject variation.
[a] Healthy school children.
[b] Children with severe generalized cerebral palsy.

In this study a facemask instead of a mouth piece was used for the measurements. Child et al.[10] showed that feasibility and reproducibility are not influenced by using a facemask or a mouth piece. The facemasks that were used in this study were not the same type in all of the participants. This might have led to an increase in the variation between participants. Per individual participant the same facemask was used for all the four measurements. Therefore it did not influence the SDw.

Further research

A limitation of the MicroRint is that it only can measure airway resistance, meaning that it can only be used in patients whom are suspected of obstructive pulmonary disease. In case of restrictive lung disease, the MicroRint will not give the information needed, as restrictive lung disease is characterized by reduced lung volume.

As long as there is no alternative method to detect both obstructive and restrictive pulmonary disease in non-cooperative persons, MicroRint may play a vital role in future screening and follow-up of obstructive pulmonary disease in persons with an intellectual disability.

For that, further research is needed. First of all it has to be investigated whether MicroRint can be used to measure reversibility. Early research by Bridge et al.[12] already has shown that the interrupter technique can be used to detect the effect of bronchodilator therapy in school children. Secondly reference values have to be established for adults, before MicroRint can be used for clinical purposes. Nevertheless, measuring airway resistance using the MicroRint seems a promising technique for this special population.

Conflict of interest statement

None of the authors have a conflict of interest to declare in relation to this work.

Acknowledgements

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