The value of nutritional assessment in major abdominal surgery
Haverkort, E.B.

Citation for published version (APA):
Chapter 3

Handgrip strength by dynamometry does not identify malnutrition in individual preoperative outpatients

E. B. Haverkort
J.M. Binnekade
R. J. de Haan
M.A.E. van Bokhorst – de van der Schueren


Abstract

Background & aims
Low handgrip strength by dynamometry is associated with increased postoperative morbidity, higher mortality and reduced quality of life. The aim of this study was to evaluate the accuracy of four algorithms in diagnosing malnutrition by measuring handgrip strength.

Methods
We included 504 consecutive preoperative outpatients. Reference standard for malnutrition was defined based on percentage involuntary weight loss and BMI. Diagnostic characteristics of the handgrip strength algorithms (Álvares-da-Silva, Klidjian, Matos, Webb) were expressed by sensitivity, specificity, positive and negative predictive value, false positive and negative rate.

Results
The prevalence of malnutrition was 5.8%. Although Klidjian showed the highest sensitivity (79%, 95%CI 62% - 90%), six out of 29 malnourished patients were falsely identified as wellnourished (false positive rate 21%, 95%CI 9% -38%). In contrast, this algorithm showed the lowest positive predictive value (8%, 95%CI 5% -13%). Matos presented the highest positive predictive value; the post-test probability increased to 13% (95%CI 8% – 20%). The 1-minus negative predictive value ranged between 3% and 5% for all algorithms.

Conclusions
None of the algorithms derived from handgrip strength measurements was found to have a diagnostic accuracy good enough to introduce handgrip strength as a systematic institutional screening tool to detect malnutrition in individual adult preoperative elective outpatients.

Key words
Surgery; Malnutrition; Handgrip strength dynamometry; Diagnostic accuracy.
Introduction

The prevalence of malnutrition in outpatients in The Netherlands ranges from 6% to 12%. Factors such as old age, diseases of the intestine, surgery for malignant disease and co-morbidity predispose to malnutrition.

As preoperative malnutrition is associated with postoperative morbidity, it is important to diagnose and treat surgical patients with malnutrition as early as possible. Nevertheless, a simple and sensitive method for screening preoperative outpatients at risk of malnutrition is lacking.

Therefore we are looking for easy markers of nutritional status that may correlate well with poor nutritional status in adult preoperative surgical outpatients.

Earlier studies that have investigated handgrip strength (HGS) at group level found significant associations between low HGS and malnutrition, postoperative complications, prolonged hospital stay, reduced ability to return home, reduced mobility, impaired quality of life and mortality.

A number of algorithms based on HGS are available to diagnose malnutrition or an increased risk for postoperative complications. Frequently used algorithms are the ones proposed by Álvares-da-Silva et al., Klidjian et al., Matos et al., and Webb et al. Each of these algorithms uses its own cut-off points of normal values and some also correct for age and sex. Nonetheless, little is known about the screening abilities of these algorithms.

The objective of this study was to investigate the accuracy of the different HGS-based tests to diagnose malnutrition at the individual level.

Patients and Methods

Design and setting

This was a cross-sectional study among patients visiting the PreOperative Screening (POS) department of the VU University Medical Center, a tertiary care university-affiliated hospital, Amsterdam, The Netherlands.

The study was approved by the local Medical Ethical Committee and qualified to improve patients’ care and carried no extra risk of harm to the patients, making written informed consent unnecessary. Patients received verbal and written information about the purpose of the study and verbal consent was given before the start of the study.

Patients

All consecutive patients between March and June 2008 ≥ 18 years of age who visited the POS department in order to be prepared for elective surgery were included in the study.

Exclusion criteria: patients who were pregnant and who had a disturbed fluid balance (e.g. edema). In addition, patients with cognitive impairment, neuromuscular diseases, hemiplegia, joint diseases and/or arthritis were also excluded since these diseases may influence HGS measurements.
Baseline assessments
Patient data (sex, age) and medical diagnosis (presence of malignancy, indication for the surgical procedure, presence of co-morbidity) were collected from medical records.

Definition and reference standard of malnutrition
Worldwide, there is a lack of agreement regarding the definition of malnutrition.\textsuperscript{21} Malnutrition is frequently defined as a state resulting from lack of uptake or intake of nutrition leading to altered body composition (decreased fat free mass but specifically body cell mass) and diminished function.\textsuperscript{22, 23} More recently, an adjusted definition has been proposed; a sub-acute or chronic state of nutrition in which a combination of varying degrees of over- or under-nutrition and inflammatory activity has led to a change in body composition and diminished function.\textsuperscript{24, 25}

We operationalized malnutrition following the ‘National Dutch Guideline Perioperative Nutrition’ by: (a) involuntary weight loss of $\geq$5% within 1 month; and/or (b) involuntary weight loss of $\geq$10% within 6 months; and/or (c) a BMI $<18.5$.\textsuperscript{26} Patients were asked by a healthcare professional (EH) to recall their weight of six months and one month prior to the study assessments in order to calculate involuntary weight loss.

Present body weight in kilograms and height in centimeters, without shoes and in light indoor clothing, were measured by a healthcare professional (EH). Weight was measured with the Seca 888\textsuperscript{©} (Seca GMBH, Hamburg, Germany); a Seca stadiometer 222\textsuperscript{©} was used for measuring height. In case of involuntary weight loss, the percentage of weight loss was calculated.

In addition patients were requested to answer a questionnaire, consisting of four components: (a) socio-demographic characteristics; (b) clinical characteristics; (c) the questions from the three most frequently used malnutrition screening tools in the Netherlands: SNAQ, MNA (for patients $\geq$ 65 years of age), and MUST; and (d) self-reported anthropometric data (height, usual body weight, present body weight, body weight one and six months prior to the study).

Handgrip strength measurement by dynamometry
After demonstrating the technique to the patient, the HGS measurements were carried out by the Jamar hydraulic dynamometer\textsuperscript{©} (Sammons Preston Inc. Illinois USA) as it demonstrates the highest calibration accuracy.\textsuperscript{28} If necessary, the instrument was adjusted to the size of the patients’ hand. The patient was sitting in a chair, his upper arm by his side of the body and the forearm stretched to an angle of 90$^\circ$, with the elbow unsupported.\textsuperscript{27-30} The HGS by dynamometry was expressed in kilograms (round down) and carried out three times by both hands.

Brief pauses were taken between each measurement. The patient was encouraged to squeeze the dynamometer as hard as possible. For all four algorithms the highest of three measurements was recorded for both the right and the left hand.
Algorithms based on HGS to diagnose malnutrition

Four different algorithms were applied to determine the absence or presence of malnutrition by hand grip strength: the algorithms by Álvares-da-Silva et al., Klidjian et al., Matos et al., and Webb et al. (Appendix 1).

Reference values and control group

For interpretation of the algorithms of Álvares-da-Silva et al., Klidjian et al., we used the reference values of a sample of 62 healthy adult volunteers visiting the hospital, with absence of co-morbidity or impairment affecting the upper limb function. HGS dynamometry procedures in the control groups were identical as described for patients. For the algorithm of Matos the reference value was defined within the study population (HGS within the lowest quartile of the population). In the algorithm of Webb we used the reference values as described in his article (Appendix 1).

Appendix 1 Definition of malnutrition as defined by the four handgrip strength (HGS) algorithms

<table>
<thead>
<tr>
<th>Algorithm ref</th>
<th>Definition of malnutrition</th>
<th>Hand to measure</th>
<th>Measurement(s) to report</th>
<th>Type of control group</th>
<th>Characteristics of control group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Álvares-da-Silva 19</td>
<td>HGS &gt; 2 SD below the mean of the control group</td>
<td>Non-dominant hand</td>
<td>The best of 3 measurements</td>
<td>Control group healthy volunteers</td>
<td>N = 62 volunteers (31 men and 31 women). Amsterdam, The Netherlands. Mean age 45 years (SD 13), range 20 - 73 years. HGS mean 44.6 kg (SD 11.6). Two SD below the mean was 21.4 kg.</td>
</tr>
<tr>
<td>Klidjian 15</td>
<td>HGS below 85% of the mean of the control group</td>
<td>Non-dominant hand</td>
<td>The best of 3 measurements</td>
<td>Control group healthy volunteers</td>
<td>N = 62 volunteers (31 men and 31 women). Amsterdam, The Netherlands. Mean age 45 years (SD 13), range 20 - 73 years. HGS mean 44.6 kg (SD 11.6). 85% of the HGS below the mean was 37.9 kg.</td>
</tr>
<tr>
<td>Matos 13</td>
<td>HGS within the lowest quartile of the study population</td>
<td>Non-dominant hand</td>
<td>The best of 3 measurements</td>
<td>Patients are their own controls</td>
<td></td>
</tr>
<tr>
<td>Webb 20</td>
<td>HGS below 85% of the reference values for age and sex of the control group</td>
<td>The non-dominant or the dominant hand</td>
<td>The best of 3 measurements</td>
<td>Control group Webb</td>
<td>Non-dominant hand: N = 247 healthy volunteers (108 Men and 139 women). London, UK. Age range 16-95 years. HGS men mean 47.5 kg (SD 9.6), HGS women mean 29.6 kg (SD 9.8). Dominant hand of subgroup of these healthy volunteers: N = 119 (53 men and 66 women). HGS men mean 48.0 kg (SD 8.9) and HGS women mean 24.7 kg (SD 10.2).</td>
</tr>
</tbody>
</table>
Diagnostic accuracy
The diagnostic accuracy was expressed in terms of sensitivity (the true-positives) and specificity (the true-negatives) rates. It was especially important to minimize the false negative rate (FNR), reflecting malnourished patients with HGS values within the normal range, as this implies missing and not treating a malnourished patient.

Additionally we calculated the predictive values of the algorithms in terms of positive predictive value (PPV) and 1-minus the negative predictive value (1-NPV). The PPV refers to the probability of being malnourished following a low HGS value, whereas the 1-NPV reflects the probability of being malnourished following an HGS value within the normal range.

Statistical analysis
Patient characteristics were summarized using descriptive statistics. Analyses on diagnostic accuracy were made on the basis of 2x2 tables, with malnutrition according to the reference standard and HGS below the normal value of the algorithm defined as present or absent.

For each HGS-algorithm the prevalence of malnutrition as well as the diagnostic accuracy parameters were calculated. When appropriate, statistical uncertainty was expressed by the 95% confidence interval (95% CI). A $P$ value of < 0.05 was considered significant. Data were analyzed with SPSS (version 16.0), STAT (version 10) and CIA (Confidence Interval Analysis).

Results
Study population
During the study period 655 eligible patients visited the POS department. Seventy-three patients declined to participate, 48 patients were excluded because of pregnancy and or extensive edema and 30 patients were excluded because of missing or inconsistent patient history data. In total, 504 patients were included. Forty-eight percent of the study population was male, the mean BMI of the population was 26.3 kg/m$^2$ (SD 4.8), and for 17% of the patients a malignancy was the indication for the surgical procedure (Table 1).

The Dutch control group consisted of 31 men and 31 women, mean age 45 years (SD 13), range 20 - 73 years. The mean HGS of the non-dominant hand of the volunteers was 44.6 kg (SD 11.6). To define the cut-off values for the algorithms of Álvares-da-Silva we calculated two standard deviations below the mean (21.4 kg); for the algorithm of Klidjian cut-off values were determined by calculating 85% below the mean (37.9 kg) (Appendix 1).

We identified 29/504 patients (5.8%) as being malnourished according to the definition of the National Dutch Guideline Perioperative Nutrition. When applying the four different algorithms, between 8.5% (Álvares-da-Silva) and 60.1% (Klidjian) of the study population was classified as malnourished (Table 1).
Table 1 Patient characteristics and prevalence of malnutrition in relation to handgrip strength (HGS) algorithms (N=504)

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>%</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>241</td>
<td>48</td>
<td></td>
</tr>
<tr>
<td>Age in years</td>
<td>51</td>
<td></td>
<td>17</td>
</tr>
<tr>
<td>Age in years, range 20 - 91</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight, kg</td>
<td>78.8</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Height, m</td>
<td>1.73</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>BMI, calculated on weight/height</td>
<td>26.3</td>
<td>4.8</td>
<td></td>
</tr>
<tr>
<td>Indication for surgical procedure – top 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neoplasm</td>
<td>85</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Diseases of bone, muscle and connective tissue</td>
<td>43</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Injuries and poisoning</td>
<td>39</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Diseases of the sense organs</td>
<td>32</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Diseases of the genitals</td>
<td>33</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Presence of co-morbidity</td>
<td>295</td>
<td>59</td>
<td></td>
</tr>
<tr>
<td>Malnutrition according to Dutch reference standard</td>
<td>29</td>
<td>5.8</td>
<td></td>
</tr>
<tr>
<td>Malnutrition according to four different algorithms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Álvares-da-Silva</td>
<td>43</td>
<td>8.5</td>
<td></td>
</tr>
<tr>
<td>Klidjian</td>
<td>303</td>
<td>60.1</td>
<td></td>
</tr>
<tr>
<td>Matos</td>
<td>118</td>
<td>23.4</td>
<td></td>
</tr>
<tr>
<td>Webb</td>
<td>84</td>
<td>16.7</td>
<td></td>
</tr>
</tbody>
</table>

The diagnostic accuracy of the four HGS algorithms

Table 2 shows the diagnostic accuracy of the four algorithms compared to our pre-set definition of malnutrition. The sensitivity of Klidjians’ algorithm was the highest at 79% (95% CI 62% - 90%). Thus, its FNR (1-sensitivity) turned out to be the lowest: six out of 29 malnourished patients (21%, 95% CI 9% - 38%) were falsely identified ‘well-nourished’ while they were identified malnourished according to our reference standard (Table 3).

The algorithms of Álvares-da-Silva and Webb showed the lowest sensitivities 14% (95% CI 6% - 31%) and 35% (95% CI 20% - 53%) respectively. Hence, the false negative test results in these algorithms were substantial. The sensitivity rate of Matos’ algorithm was moderate (52%, 95% CI 34% - 69%).

As shown in Table 1 the prevalence or pre-test probability for being malnourished was 5.8% (29/504 patients). As expressed by the PPVs column in Table 2, the algorithm of Matos modestly increased the post-test probability of being malnourished following a poor HGS
value to a point estimate of 13% (95% CI 8% – 20%), directly followed by the PPV of Webb; 12% (95% CI 7% – 21%).

The 1-minus NPVs, expressing the probability of malnourished patients with an adequate HGS value, hardly decreased compared to the pre-test probability and ranged between 3% and 5% for all algorithms.

### Discussion

This cross-sectional study among elective adult preoperative patients visiting the preoperative screening department showed that none of the algorithms that we studied performed well enough to diagnose malnutrition by HGS sufficiently at the individual patient level. The approach of Klidjian resulted in the highest sensitivity rate compared to the

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Sensitivity (TPR) a</th>
<th>Specificity (TNR) b</th>
<th>PPV c</th>
<th>1-NPV d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Álvares-da-Silva</td>
<td>14 (6 - 31)</td>
<td>92 (89 - 94)</td>
<td>9 (4 – 22)</td>
<td>5 (4 – 8)</td>
</tr>
<tr>
<td>Klidjian</td>
<td>79 (62 - 90)</td>
<td>41 (37 - 46)</td>
<td>8 (5 – 11)</td>
<td>3 (1 – 6)</td>
</tr>
<tr>
<td>Matos</td>
<td>52 (34 - 69)</td>
<td>78 (74 - 82)</td>
<td>13 (8 – 20)</td>
<td>4 (2 – 6)</td>
</tr>
<tr>
<td>Webb</td>
<td>35 (20 - 53)</td>
<td>84 (81 - 87)</td>
<td>12 (7 – 21)</td>
<td>4 (3 – 7)</td>
</tr>
</tbody>
</table>

The prevalence of malnutrition based on the reference standard was 5.8%.

a Sensitivity = TPR (true positive rate) expressed in % (95% CI)
b Specificity = TNR (true negative rate) expressed in % (95% CI)
c PPV = positive predictive value expressed in % (95% CI)
d 1-NPV = 1 - negative predictive value expressed in % (95% CI)
other screening tools. Nevertheless, one-fifth of the malnourished patients was falsely identified as ‘well-nourished’ using this algorithm. In addition, compared to the pre-test probability of malnutrition, the post-test probability to be malnourished following a poor HGS value did not increase substantially with any of the algorithms.

Elderly and cancer patients are at increased risk to develop malnutrition. To study whether there were differences between the total population and these high risk groups, we performed post-hoc analyses in these groups. The algorithm of Klidjian, in contrast to the other algorithms, performed very well in the subgroup of patients ≥65 years of age (n=118) with a sensitivity of 100% (95% CI 68% – 100%). We suggest a more thorough evaluation of the added value of HGS in older preoperative patients’ in a future study. In cancer patients (n=85), the post-hoc analyses showed that the algorithms performed comparable to the total population.

We have tried to explain the poor diagnostic accuracy of the four algorithms. First of all, the lack of accuracy may be caused by unreliable measurements. We used the Jamar hydraulic dynamometer, the instrument with the highest calibration accuracy, and the procedure was performed by one single clinical experienced researcher (EBH), according to a standardized protocol, as described by Mathiowetz et al. Therefore, we do not believe that the instrument or the caregiver significantly influenced the result.

A more plausible explanation for the poor accuracy may be found in the existing reference values and methods. Can HGS values measured in relatively small groups of (healthy) adults living in the UK, USA, Portugal or Brazil be extrapolated to Dutch patients being worked-up for surgery? In addition to other factors, HGS depends on the stature or constitution of a population. Autochthonic Dutch inhabitants are relatively tall and it is assumed that this may result in a basic increase of HGS. Probably, HGS ratios (dividing the measured HGS in kg by the square of body height in meters) would be more valid, although reference values are not yet available.

As HGS is also age related, we evaluated whether age may have caused the lack of diagnostic accuracy to identify malnutrition in our population of patients. The age of our patients was comparable to the control groups provided by Webb et al., thus not explaining the poor diagnostic accuracy by that algorithm. However, our healthy controls were, on average, 6 years younger than our patients. To study whether this may have influenced the results, we, post-hoc, applied the sex and age specific normative data for handgrip strength described in a meta-analysis by Bohannon et al., to the algorithms of Álvares-da-Silva et al. and Klidjian et al. instead of the reference values of our healthy volunteers. Results revealed even lower sensitivities and higher FNR for both algorithms and a PPV of 8% for Álvares-da-Silva and 11% for Klidjian.

HGS is often used as a predictor of postoperative complications, but this was not the aim of the present study. However, in future we will study in greater detail the predictive value of HGS as well as the value of repeated HGS measurements on one person in relation to postoperative outcome.
This study has some limitations. Only 29 out of 504 patients were found to be malnourished according to the reference standards that we applied (involuntary weight loss and/or a low BMI). Therefore, conclusions drawn from a dataset with low prevalence rate must be interpreted with caution.

For the algorithms of Álvares-da-Silva et al. and Klidjian et al., we used our own control group that consisted of 62 healthy volunteers; this small number of controls may be regarded as a limitation of the study.

The normative HGS data of the research group of Mathiowetz could not be used in this study. Our written communication with the researcher makes clear that he never focused on identifying malnourished patients, but on helping occupational therapists and physiotherapists to identify patients who are in need of hand strengthening. For that purpose it has been suggested that a patient scoring more than 3 SD below the mean for their age and gender are likely to need hand strengthening; those scoring 2 SD below the mean might need hand strengthening. Since the algorithm of Mathiowetz et al. has not been designed to diagnose malnutrition, a cut-off value for malnutrition could not be recommended and the algorithm, in its present form, is inappropriate for identification of malnourished patients.

Finally, there seems to be a critical extent of body protein loss that must occur before decomposition of vital physiological functions (e.g. a perceptible reduction of muscle strength and muscle function) will appear. Only 15/29 (52%) malnourished patients in our population had lost >10% of their body weight within 6 months before the study. This may explain why HGS was not always reduced and remained within the normal range for age and gender, although we identified those patients as malnourished.

If true prevalence rates are as low as in our study, one should question the effectiveness and efficacy of performing (time-consuming) measures such as HGS in this target population.

In a previous study we evaluated the diagnostic accuracy of self-reported anthropometry data (height and weight), and three well-known screenings tools (SNAQ, MNA (in the elderly subpopulation) and MUST) to diagnose malnutrition in the same population as the current study. The self-reported data showed a higher sensitivity and specificity than any of the three applied screening tools. Results of this study, suggest that self-reported anthropometry data may be considered as a more accurate and easier alternative.

**Conclusion**

We showed that the algorithms of Álvares-da-Silva, Klidjian, Matos and Webb to diagnose malnutrition by measurement of HGS lack sufficient diagnostic accuracy. Our study results do not confirm HGS as an accurate alternative to systematically screen for malnutrition in elective preoperative outpatients.
Acknowledgements

The authors have no disclosure of interest regarding the article. The authors’ contributions; study conception and design: EH, MvB. Acquisition of data: EH. Analysis and interpretation of data: EH, RdH, JB. Drafting of manuscript: EH, RdH, JB, MvB. Critical revision: EH, RdH. All authors have actively contributed, read and approved the final manuscript.

We acknowledge Marloes Bakker, Marieke Berkhout, Marcella Martin and Leonie Roeleveld for their assistance during the study (at the time of the study students from the School of Sports and Nutrition (Department of Nutrition and Dietetics), Amsterdam, The Netherlands).

References

18. Jakobsen LH, Rask IK, Kondrup J. Validation of handgrip strength and endurance as a measure of physical


Letter to the Editor

Sir,

Haverkort et al. investigated the accuracy of handgrip strength (HGS) in diagnosing undernutrition. They indicated that “algorithms based on HGS are available to diagnose malnutrition” and they studied their diagnostic accuracy using previously published cut-offs for estimates of sensitivity and specificity. One of these used cut-offs corresponds to the 25th percentile of HGS distribution values of a hospitalized sample evaluated by our research group. The used cut-off was only a way to overcome the absence of reference HGS values to screen hospital undernutrition and not a systematic instruction to diagnose this condition or an “algorithm”, according to Haverkort et al. terminology.

Indeed, the screening ability of these cut-offs should a priori have a limited application to their sample of preoperative outpatients, whose HGS values are not shown, but are presumably higher.

The reference method used by Matos et al. to test HGS was the “Nutritional Risk Screening 2002” which is composed by nutritional status dimensions that have previously shown to have high validity in predicting nutritional risk. Contrary, the tool used by Haverkort et al. is based only on changes in body mass or BMI, which is expected to have a different association with HGS. Also, the sample used by Haverkort et al. has a low frequency of undernourished patients, limiting its ability to evaluate the diagnostic value of HGS. Finally, the dynamometers used in these two studies were different, limiting the comparability of the HGS values.

For these reasons we consider that this design is not appropriate to answer the relevant question whether HGS identifies undernutrition in preoperative outpatients and we strongly encourage the authors to test it against their own distribution values.

T.F. Amaral
J. Mendes
Faculdade De Ciências Da Nutrição E Alimentação Da, Universidade Do Porto, Rua Dr Roberto Frias, 4200-465 Porto, Portugal

References
Response from the authors

Handgrip strength reconsidered: Continuous poor accuracy to diagnose malnutrition in preoperative outpatients

Sir,

We thank Dr. Mendes and Professor Dr. Amaral for their comments regarding our recent paper on the accuracy of handgrip strength (HGS) to diagnose malnutrition in preoperative outpatients. We hope that they do not disagree with the central premise of our study: the necessity to diagnose and treat preoperative malnourished patients as early as possible to avoid negative effects in the postoperative phase.

A simple and sensitive method for screening on malnutrition is lacking for (preoperative) outpatients. We therefore studied not only the accuracy of HGS, but also that of self-reported anthropometric data and the screenings tools SNAQ, MNA (for patients ≥ 65 years of age) and MUST to diagnose malnutrition in a large heterogeneous group of preoperative outpatients.

The remarks of Dr. Mendes and Professor Dr. Amaral relate to two aspects: 1. Failure to use the NRS-2002 as the gold standard to screen for malnutrition 2. The use of the HGS in the lowest quartile of the study population as a cut-off point to determine malnutrition.

We deliberately did not choose the NRS-2002 as the gold standard to define malnutrition. The reason is that NRS-2002 has not been validated for the outpatient setting. Especially the item ‘severity of disease’ focuses typically on clinical patients, which hinders the applicability of the tool for use in outpatients. Moreover, in an extensive literature search we have not been able to identify any papers describing the validity of NRS-2002 for outpatients. Matos et al. described that the accuracy of HGS compared to NRS-2002 was the highest for the lowest quartile. Therefore, we decided to use the lower quartile as a cut-off point in our study.

In answer to the remarks of Dr. Mendes and Professor Dr. Amaral we performed a post-hoc analysis. In 419 patients we were able to collect reliable data with regard to our definition of malnutrition (involuntary weight loss / low BMI), the four HGS algorithms, self-reported anthropometric data, the earlier mentioned screening tools and the NRS-2002.

The prevalence of malnutrition according to our reference method was 5.3% (22/419) in this group. According to the NRS-2002 this was 15.3% (64/419). When we applied the NRS-2002 instead of our reference method as the gold standard, this - remarkably - resulted in equal (poor) accuracy for the Matos equation: Sensitivity for both references 45%, specificity 80% and 83% respectively (Table 1). These new results show that the NRS-2002 does not positively affect the diagnostic accuracy of HGS in preoperative outpatients. As prevalence rates varied widely we also calculated the positive likelihood ratio (LR+). This also resulted in almost identical values (2.2 and 2.6 respectively).

We agree with the remark that the dynamometers used in these two studies were different. We used the Jamar hydraulic dynamometer© as this is the instrument with the
highest calibration accuracy according to Mathiowetz et al.\textsuperscript{3}

In conclusion: we endorse the view that there is no global definition of malnutrition and that there is uncertainty about the instrument that can determine malnutrition the best. We maintain our view that, regardless the reference method, HGS is no accurate method to determine preoperative malnutrition in a heterogeneous group of preoperative outpatients.

E.B. Haverkort
Department of Nutrition and Dietetics, Internal Medicine, VU University Medical Center, Amsterdam, The Netherlands. Department of Dietetics, Academic Medical Center, University of Amsterdam, Amsterdam, The Netherlands.

J.M. Binnekade
Department of Intensive Care, Academic Medical Center, University of Amsterdam, Amsterdam, The Netherlands.

Marian A.E. van Bokhorst - de van der Schueren
Department of Nutrition and Dietetics, Internal Medicine, VU University Medical Center, Amsterdam, The Netherlands.
Table 1 Diagnostic accuracy of the four handgrip strength (HGS) algorithms and self-reported anthropometric data compared to two different reference methods (1) involuntary weight loss/low BMI and (2) NRS-2002 (N=419)

<table>
<thead>
<tr>
<th>Reference method</th>
<th>Sensitivity (TPR) a in % (95% CI)</th>
<th>Specificity (TNR) b in % (95% CI)</th>
<th>Positive likelihood ratio (LR+) c</th>
</tr>
</thead>
<tbody>
<tr>
<td>Álvares-da-Silva</td>
<td>WL/low BMI d 9 (3 – 28)</td>
<td>92 (89-94)</td>
<td>1.1</td>
</tr>
<tr>
<td>NRS-2002</td>
<td>14 (8 – 25)</td>
<td>93 (90 – 95)</td>
<td>2.0</td>
</tr>
<tr>
<td>Klidjian</td>
<td>WL/low BMI d 77 (57 – 90)</td>
<td>43 (38-48)</td>
<td>1.4</td>
</tr>
<tr>
<td>NRS-2002</td>
<td>72 (60 – 81)</td>
<td>45 (39 – 50)</td>
<td>1.3</td>
</tr>
<tr>
<td>Matos</td>
<td>WL/low BMI d 45 (27 – 65)</td>
<td>80 (75 – 83)</td>
<td>2.2</td>
</tr>
<tr>
<td>NRS-2002</td>
<td>45 (34 – 57)</td>
<td>83 (78 – 86)</td>
<td>2.6</td>
</tr>
<tr>
<td>Webb</td>
<td>WL/low BMI d 32 (16 – 53)</td>
<td>85 (81 – 88)</td>
<td>2.1</td>
</tr>
<tr>
<td>NRS-2002</td>
<td>27 (17 – 39)</td>
<td>86 (82 – 89)</td>
<td>1.9</td>
</tr>
<tr>
<td>Self-report</td>
<td>WL/low BMI d 95 (78 – 99)</td>
<td>98 (96 – 99)</td>
<td>42.1</td>
</tr>
<tr>
<td>NRS-2002</td>
<td>25 (16-37)</td>
<td>96 (94 – 98)</td>
<td>6.3</td>
</tr>
</tbody>
</table>

Prevalence of malnutrition: 5.3% according to WL/low BMI (involuntary weight loss and low BMI) and 15.3% according to NRS-2002.

a Sensitivity = TPR (true positive rate) expressed in % (95% CI)

b Specificity = TNR (true negative rate) expressed in % (95% CI)

c Positive likelihood ratio (LR+) = (a / [a + c]) / (b / [b + d])

d Malnutrition was defined following the ‘National Dutch Guideline Perioperative Nutrition’ by: (a) involuntary weight loss of ≥5% within 1 month; and/or (b) involuntary weight loss of ≥10% within 6 months; and/or (c) a low BMI (BMI <18.5 for patients younger than 65 years and BMI < 20.0 for patients 65 years and older)

References