Knee replacement outcome predicted by physiotherapists: a prospective cohort study

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Background: Knee arthroplasty (KA) is commonly used for osteoarthritis of the knee joint and it is a highly successful procedure. Still, KA leaves 20% of patients dissatisfied with their outcome. The purpose of this study was to determine if a prognosis made by physiotherapists at the orthopaedic wards during the first post-operative days could predict the 6- and 12-months outcome of KA.

Methods: Physiotherapists at two orthopaedic wards in Denmark were asked to predict the 6- and 12-months outcome of the KA patients they have treated post-operatively on a 0-10 scale (10 representing the best prognosis). At 6 and 12 months post-operatively the patients answered the Oxford Knee Score (OKS), EuroQol 5D-3L and Patient Acceptable Symptom State (PASS). Multivariable logistic regression analyses were performed to assess the prediction of PASS and treatment success. We assessed predictive performance by examining measures of calibration and discrimination.

Results: 361 patients were included. The models for PASS and Treatment Success showed poor to acceptable discriminative values (OR between 1.47 and 1.92 and areas under the curves of 0.62-0.73), however the calibration plots indicated significant uncertainties in the prediction.

Conclusion: Physiotherapists prognoses of recovery after KA are associated with 6- and 12-months patient reported outcomes and satisfaction but have weak predictive value. This study suggests that physiotherapists' prognoses may be useful as an additional source of information when identifying patients in need of additional post-operative care.

1 **KNEE REPLACEMENT OUTCOME PREDICTED BY PHYSIOTHERAPISTS: A**

2 **PROSPECTIVE COHORT STUDY**

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19 **Abstract**

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21 it is a highly successful procedure. Still, KA leaves 20% of patients dissatisfied with their

22 outcome. The purpose of this study was to determine if a prognosis made by physiotherapists at

23 the orthopaedic wards during the first post-operative days could predict the 6- and 12-months

24 outcome of KA.

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28 Oxford Knee Score (OKS), EuroQol 5D-3L and Patient Acceptable Symptom State (PASS).

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30 treatment success. We assessed predictive performance by examining measures of calibration

31 and discrimination.

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33 to acceptable discriminative values (OR between 1.47 and 1.92 and areas under the curves of

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36 months patient reported outcomes and satisfaction but have weak predictive value. This study

37 suggests that physiotherapists' prognoses may be useful as an additional source of information

38 when identifying patients in need of additional post-operative care.

39

40 **Introduction**

41 Knee arthroplasty (KA) is considered a successful orthopaedic procedure to alleviate knee pain

42 and disability in knee osteoarthritis (OA) and the demand for KA is large and growing

43 worldwide (Ackerman et al. 2019; Culliford et al. 2015; Nemes et al. 2015). Despite being

44 considered a generally safe and successful procedure, there is a significant proportion (20%) of

45 patients who endure years of disability and dissatisfaction with their postoperative function

46 (Bourne et al. 2010; Gunaratne et al. 2017; Kahlenberg et al. 2018). Many of these patients do

47 not undergo revision surgery, but all add to the society's burden of health care as clinicians and

48 allied services strive to remedy their dissatisfaction.

49 While efforts have been made to predict the best candidates for KA (Birch et al. 2019;

50 Harbourne et al. 2019; Judge et al. 2012) it has proven very difficult to identify robust pre-

51 operative prognostic factors (Gunaratne et al. 2017). It is important to be able to identify

52 inappropriate candidates pre-operatively, but until that is possible, efforts to improve post-

53 operative rehabilitation and identify individuals that may need special attention post-operatively

54 is equally important.

55 Physiotherapists play an important role in the post-operative treatment of patients that have

56 received a KA. In general patients are mobilised very early, and rehabilitation is commenced

57 during the first days after surgery (or even on the same day) while the patient is still hospitalised.

58 There are numerous factors that can predict the outcome of KA, of which most are either poor

59 predictors or unsatisfactorily assessed scientifically (Harmelink et al. 2017). In daily clinical

60 physiotherapy practice at the orthopaedic wards, previous experiences, knowledge, and personal

61 interaction with a patient altogether result in the physiotherapist's intuition about the future

62 course of a patient's recovery. Previously, it has been shown that physiotherapists' prognoses

63   during the initial clinical encounter for the projected outcome of patients with low back and neck

64   pain they treated, was associated with the actual clinical outcome (Cook et al. 2015). However, it

65   is unknown if such intuition is a reliable predictor of the outcome of KA.

66   With this study we aimed to assess if physiotherapists treating inpatients at orthopaedic wards

67   could predict the 6- and 12-months post-operative self-reported pain, functional status and health

68   related quality of life of patients undergoing KA.

69

70   **Materials & Methods**

71   The study is a prospective, pragmatic, longitudinal cohort study conducted from December 2016

72   to December 2019 with a 6- and 12-month follow-up. The study was conducted according to a

73   prespecified protocol, which was pre-registered and submitted to the Health Research Ethics

74   Committee of The Capital Region of Denmark (file number: 16039254). The committee deemed

75   the study exempt from approval as the study only uses questionnaire data. Such studies can be

76   implemented without approval from the Health Research Ethics Committee according to Danish

77   legislation. The prespecified study protocol was pre-registered at www.clinicaltrials.gov

78   (Identifier: NCT02982785) prior to data collection.

79

80   **Participants**

81   Participants were recruited from the orthopaedic wards at Bispebjerg-Frederiksberg Hospital and

82   Herlev-Gentofte Hospital in Copenhagen, Denmark. The inclusion criteria were: Primary total

83   KA for knee OA; Age >18 years; Read and speak Danish and having an email-address. The

84   exclusion criteria were: Revision surgery and cognitive or mental conditions precluding reliable

85 answers to online questionnaires (determined either from medical records or judged by the

86 including physiotherapists). All participating patients signed an informed consent.

87

88 **Procedures**

89 During the post-operative hospital stay, eligible participants were identified by the

90 physiotherapists and invited to participate in the study. Upon signed informed consent, baseline

91 data were collected using standardized forms. At discharge, physiotherapists delivering the initial

92 in-patient physiotherapy and mobilization judged the participants' prognosis (see below).

93 Study data were collected and managed using REDCap electronic data capture tools hosted at

94 The Capital Region of Denmark (Harris et al. 2019; Harris et al. 2009). REDCap (Research

95 Electronic Data Capture) is a secure, web-based software platform designed to support data

96 capture for research studies, providing 1) an intuitive interface for validated data capture; 2)

97 audit trails for tracking data manipulation and export procedures; 3) automated export procedures

98 for seamless data downloads to common statistical packages; and 4) procedures for data

99 integration and interoperability with external sources. Via REDCap, individual internet-

100 hyperlinks were emailed to the participants 6 and 12 months after discharge. The hyperlinks led

101 to a secured webpage on which the patients answered questionnaires. The participant-submitted

102 responses were automatically registered in a secured database. At both 6- and 12-months data

103 collection points an email reminder was sent to participants if they did not answer the

104 questionnaires within 7 days.

105

106 **Physiotherapists' prognoses**

107   The physiotherapists estimated each patient's potential for a successful outcome after 6-12

108   months at discharge based on professional appraisal. The physiotherapists were asked to appraise

109   all parts of their evaluation in their prognosis of each patient. The physiotherapists were

110   instructed to score each patient on a 1-10 Likert scale (1 representing a very poor projected

111   outcome, 10 representing an excellent projected outcome). The physiotherapists scored each

112   patient following their complete encounter with the patient. This included the physiotherapist's

113   assessment of the patient's resources (personal, material, social, etc.), personality, medical

114   history, comorbidities, surgery reports, physical examination(s), in-patient physiotherapy

115   treatment response(s), physiotherapeutic (re)assessments, and more. The prognosis was not

116   disclosed to the participants.

117

118   Outcomes

119   The primary outcome measure was the Oxford Knee Score (OKS). The Oxford Knee Score

120   (OKS) is a 12-item Patient Reported Outcome questionnaire developed specifically to assess the

121   patient's perspective of outcome following KA (Dawson et al. 1998). Standardized answer

122   options are given (5 Likert boxes) and each question is assigned a score from 0 to 4. A total score

123   is calculated that ranges from 0 and 48, with 48 indicating the best outcome. The OKS is short,

124   practical, reliable, valid, and sensitive to clinically important changes over time (Dawson et al.

125   1998). The OKS scores were dichotomised using an established cut-off value for treatment

126   success after TKA of 32.5 points (Hamilton et al. 2018). The dichotomised OKS was labelled as

127   'Treatment Success' for scores above 32.5 at both 6- and 12-months follow-up.

128   In addition to the single OKS summary score, we also calculated the OKS pain and OKS

129   function sub-scale scores that were standardized to a range from 0 (worst) to 100 (best).

130   Health outcome and quality of life was assessed using the European Quality of Life (EuroQoL)

131   questionnaire (EQ-5D-3L). EQ-5D-3L is a standardized patient-reported instrument for use

132   measuring health outcome and quality of life (EuroQol 1990). EQ-5D-3L is designed for self-

133   completion by respondents and is ideally suited for use in surveys.

134   The EQ-5D-3L consists of a descriptive system and a Visual Analogue scale (EQ-5D-VAS). The

135   descriptive system comprises 5 dimensions (mobility, self-care, usual activities, pain/discomfort,

136   and anxiety/depression). Standardized answer options are given (3 Likert boxes) and each

137   question is assigned a score from 1 to 3. From the answers an EQ-5D-3L index score is

138   calculated based on Danish normative equations. The index ranges from -0.624 (worst) to 1.000

139   (best). The EQ-5D-VAS records the respondent's current self-rated health on a 10 cm Visual

140   Analogue Scale (VAS) with endpoints labelled '*the best health you can imagine*' and '*the worst*

141   *health you can imagine*'.

142   We also applied a single question regarding the Patient Acceptable Symptom State (PASS)

143   (Tubach et al. 2005) to assess the patient´s satisfaction with their state of symptoms at 6 and 12

144   months after surgery. PASS is assessed as a dichotomous outcome (yes/no) to the question:

145   "*Considering your knee function, do you feel that your current state is satisfactory? With knee*

146   *function you should take into account all activities you have during your daily life,*

147   *Sport/Recreational activities, your level of pain and other symptoms, and your knee related*

148   *QOL*".

149   **Statistical analyses**

150   The 6- and 12-months follow-up data were analyzed separately. The associations between the

151   physiotherapists' prognostic scores and the dichotomous PASS and Treatment Success variables

152   were assessed using logistic regression analyses with the physiotherapists' prognostic scores as

153   independent variable and PASS ('yes') and Treatment Success as dependent variables.

154   The predictive performance of the physiotherapists' prognostic scores was analysed using

155   calibration and discrimination measures. Discrimination relates to the ability of the model to

156   discriminate between patients who have answered 'yes' to the PASS question or achieved

157   Treatment Success from those who have answered 'no' or did not achieve Treatment Success.

158   These were evaluated by calculating the areas under the receiver operating characteristic curves

159   (AUC) and Nagelkerke R^2 as an indication of explained variation. Calibration relates to the

160   agreement between the projected and observed outcome and was evaluated by means of

161   calibration plots, in which patients were classified by the predicted risk of the observed

162   prognostic scores, supplemented by loess lines over the predicted probability range. The loess

163   line of a prefect prediction model lies on the 45° slope for agreement with the observed outcome.

164   The associations between the physiotherapists' prognostic scores and the continuous variables

165   OKS, OKS-pain, OKS-function, EQ-5D-3L index and EQ-5D-VAS were assessed by univariate

166   linear regression analyses with the physiotherapists' prognostic scores as independent variable

167   and OKS, OKS-pain, OKS-function, EQ-5D-3L and EQ-5D-VAS as dependent variables. The

168   associations were assessed via the estimated slopes (beta) and explained variance (R^2).

169   P-values of <0.05 were considered statistically significant.

170

171 **Results**

172 From December 2017 to December 2018 a total of 382 individuals (57% women) were invited to

173 participate (**Table 1**). Of these 20 were not eligible and 1 did not have a prognostic score.

174 Accordingly, 361 patients were included with a mean age of 69.2 years (SD 7.9). There were 42

175 patients who did not respond to any survey or reminders, 16 who responded to the 6-month but

176 not the 12-month survey, and 12 who did not respond to the 6-months but responded to the 12-

177 month survey (**Figure 1**). Thus, at the 6-month follow-up 307 answered the survey and at 12

178 months 303 answered the survey.

179

180 The prognostic scores ranged from 4 to 10, with a mean of 8.3 (SD 1.2) and the median being 9

181 (**Table 1**). Summaries of the outcome variables are presented in **Table 2**.

182

183 At the 6-month follow-up, the incidence of positive answers ('yes') to the PASS was 240 (78%)

184 and Treatment Success (OKS>32.5) was 251 (82%). At the 12-month follow-up the incidence of

185 positive PASS answer was 255 (85%) and of Treatment Success was 251 (83%).

186

187 A high prognostic score increased the odds of achieving PASS ('yes') at 6 months (OR = 1.47

188 (95% confidence interval 1.19 to 1.82)) and at 12 months (OR = 1.45 (95% CI 1.14 to 1.84)).

189 Similarly, a high prognostic score increased the odds of Treatment Success at 6 months (OR =

190 1.62 (95% 1.29 to 2.03)) and at 12 months (OR = 1.92 (95% CI 1.51 to 2.46)).

191

192 The performance of these models in terms of discrimination is presented in **Table 3**. The

193 prediction of positive answer to the PASS and Treatment Success at 6 months showed

194   statistically significant yet poor discrimination (AUC 0.62 and 0.67, respectively). At 12 months

195   the prediction of positive answer to the PASS and Treatment Success showed poor to acceptable

196   discrimination (AUC 0.64 and 0.73, respectively).

197

198   The calibration of the models in the validation cohort is presented using calibration curves

199   (**Figure 2**) showing the performance of the models for PASS and Treatment Success at 6 and 12

200   months.

201

202   The results of the univariate regression analyses used to assess the prediction of the continuous

203   outcomes are given in **Table 4**. The prognostic score was statistically significantly associated

204   with all the dependent variables at both 6 and 12 months, although with limited explained

205   variance ($R^2 < 0.12$; **Table 4**).

206

Discussion

207

208   In summary these findings support the hypothesis, that the prognostic scores of future outcomes

209   made by physiotherapists attending patients undergoing KA in the first days postoperatively

210   associate with the 6- and 12-month outcomes of KA. The discriminative performance can be

211   considered poor to acceptable. However, the AUC and ROC curve analyses did not suggest a

212   cut-off value that may be used to screen patients. Although the calibration plots suggest a linear

213   relationship between the predicted and observed probability of PASS and Treatment Success

214   there are significant uncertainties as judged by the 95% confidence intervals. From Figure 2 is

215   can be seen that the uncertainties (width of the 95% CI) are related to the distribution of the

216   predicted probabilities. This is likely due to the small number of patients with low prognostic

217   scores (table 1). The linear regressions show that the physiotherapists' prognostic scores are

218   associated with the 6- and 12-months outcomes. Altogether the data suggest that the

219   physiotherapists' prognoses associate with the outcomes, but the predictive values of the scores

220   are not convincible. Thus, the physiotherapists' prognostic scores should be supported by other

221   information and individual assessments (such as age, sex, body weight, post-operative pain and

222   mobility, comorbidities etc.), when the future course of a patient is discussed and decisions about

223   possible extra attention is taken. Further studies on defining patients that may not have

224   successful outcomes of KA are needed.

225   The present study is the first on physiotherapists' prognoses of KA. Previously, it has been

226   shown that physiotherapists' prognoses during the initial clinical encounter for the projected

227   outcome of patients with low back and neck pain they treated, was associated with the actual

228   clinical outcome (Cook et al. 2015).

229   A strength to the present study is the use of outcomes widely accepted for assessing outcomes of

230   KA (Conner-Spady et al. 2018; Dunbar et al. 2001; Garratt et al. 2004; Jin et al. 2019). The total

231   mean OKS score of the cohort, is comparable with the ones found in other studies (Williams et

232   al. 2013a; Williams et al. 2013b), which support the external validity of the results. Also, the

233   relatively large cohort provides some strength to the study. Further, the fact that the

234   physiotherapists who made the prognoses were not involved in delivery of any post-operative

235   rehabilitation is a significant strength as they could not influence the rehabilitation. Finally, it is a

236   strength that the study was carried out on two independent hospitals in Denmark, which

237   strengthen the generalizability of the results.

238   The study also has some limitations. Firstly, other types of information (such as pain intensity

239   and functional disability, body weight, comorbidities etc.) from the pre-operative and first post-

240   operative days could have been useful in identification of potentially modifiable factors (such as

241   body weight, muscle strength, functional disability, adjustment in treatment of comorbidities)

242   that associate with the prognoses. Such information could have helped identifying the underlying

243   factors that the physiotherapists based their prognoses on and used to propose future

244   interventions to mitigate negative outcomes. Further, the distribution of the prognostic scores

245   were skewed, with few low scores, which probably reflects the general successfulness of KA and

246   that the physiotherapists in general expect positive outcomes. Nevertheless, about 15% of the

247   patients did not reach PASS or Treatment Success after 12 months and could be candidates for

248   special post-operative attention . In this perspective, the physiotherapist prognosis may be used

249   to inform the identification of patients who may benefit from more intensive post-operative care

250   in order to enhance the outcome of KA. However, the present data suggest that such

251   identification should not rely solely on the physiotherapists prognoses but should incorporate

252 other sources of information. Also, the instruments used to assess treatment success and patient

253 satisfaction (OKS and PASS) does not necessarily cover all aspects, as numerous factors

254 determine these. An OKS score above 32.5 (treatment success) does not necessarily indicate

255 success for the patient and the single yes/no PASS answer is not exhaustive. Several instruments

256 to assess patient satisfaction after KA exist (Kahlenberg et al. 2018), yet there is no consensus on

257 which instrument to use to assess treatment success or patient satisfaction. However, these

258 instruments (OKS and PASS) are widely used in OA and KA clinical and research settings.

259

260 **Conclusions**

261 In conclusion, physiotherapists prognoses of recovery after KA are associated with 6- and 12-

262 months patient reported outcomes and satisfaction but have weak predictive value. This study

263 suggests that physiotherapists' prognoses may be useful as an additional source of information

264 when identifying patients in need of additional post-operative care.

265

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342

Age, sex and prognostic scores at baseline among all invited participants and the survey responders.

1   **Table 1.** Age, sex and prognostic scores at baseline among all invited participants and the survey
2   responders.

	All (n=361)	Respondents at 6 months (n=307)	Respondents at 12 months (n=303)
Age	69.2 (7.9)	68.6 (7.9)	68.8 (7.8)
Female, n(%)	207 (57%)	176 (57%)	172 (57%)
PT Prognosis, n(%)			
10	59 (16%)	54 (18%)	55 (18%)
9	127 (35%)	109 (35%)	102 (34%)
8	96 (27%)	81 (26%)	82 (27%)
7	48 (13%)	37 (12%)	39 (13%)
6	21 (6%)	17 (6%)	18 (6%)
5	8 (2%)	7 (2%)	6 (2%)
4	2 (1%)	2 (1%)	2 (1%)
PT, Physiotherapist			

Group means and standard deviations (SD) in the different outcome measures at the 6- and 12-months follow-up.

1   **Table 2.** Group means and standard deviations (SD) in the different outcome measures at the 6- and 12-
2   months follow-up.

	Mean (SD)
OKS (0-48)	
6 months	37.6 (7.4)
12 months	39.7 (7.7)
OKS pain (0-100)	
6 months	80.2 (16.9)
12 months	84.7 (16.8)
OKS function (0-100)	
6 months	77.4 (15.9)
12 months	80.0 (16.8)
EQ-5D-3L index (-0.624 to 1.000)	
6 months	0.843 (0.145)
12 months	0.868 (0.153)
EQ-5D VAS (0-100)	
6 months	78.9 (16.7)
12 months	79.5 (18.3)
OKS: Oxford Knee Score; EQ-5D: EuroQoL 5 Dimensions; VAS: Visual Analog Scale	

Performance of prediction.

1 **Table 3.** Performance of prediction.

	AUC (95% CI)	R^2
PASS negative answer		
6 months	0.62 (0.54 to 0.70)	0.06
12 months	0.64 (0.56 to 0.73)	0.05
No Treatment Success		
6 months	0.67 (0.59 to 0.75)	0.09
12 months	0.73 (0.65 to 0.80)	0.16
AUC: Area Under the Curve; CI: Confidence Interval; PASS: Patient Acceptable Symptom State		

Results of the univariate linear regression analyses with the physiotherapists' prognostic scores as predictor

1 **Table 4.** Results of the univariate linear regression analyses with the physiotherapists' prognostic scores
2 as predictor

Dependent variable	6 months			12 months		
	Slope (95%CI)	P	R^2	Slope (95%CI)	P	R^2
OKS	1.9 (1.2 to 2.5)	<0.0001	0.10	2.1 (1.5 to 2.8)	<0.0001	0.12
OKS Pain	4.0 (2.5 to 5.4)	<0.0001	0.08	4.5 (3.0 to 5.9)	<0.0001	0.11
OKS Function	3.9 (2.5 to 5.2)	<0.0001	0.09	4.4 (2.9 to 5.8)	<0.0001	0.10
EQ-5D-3L Index	0.03 (0.02 to 0.05)	<0.0001	0.08	0.04 (0.03 to 0.06)	<0.0001	0.12
EQ-5D VAS	3.2 (1.8 to 4.7)	<0.0001	0.06	3.6 (2.0 to 5.2)	<0.0001	0.06
OKS: Oxford Knee Score; EQ-5D: European Quality of Life 5 dimensions; VAS: Visual Analog Scale						

Figure 1

Study flow chart
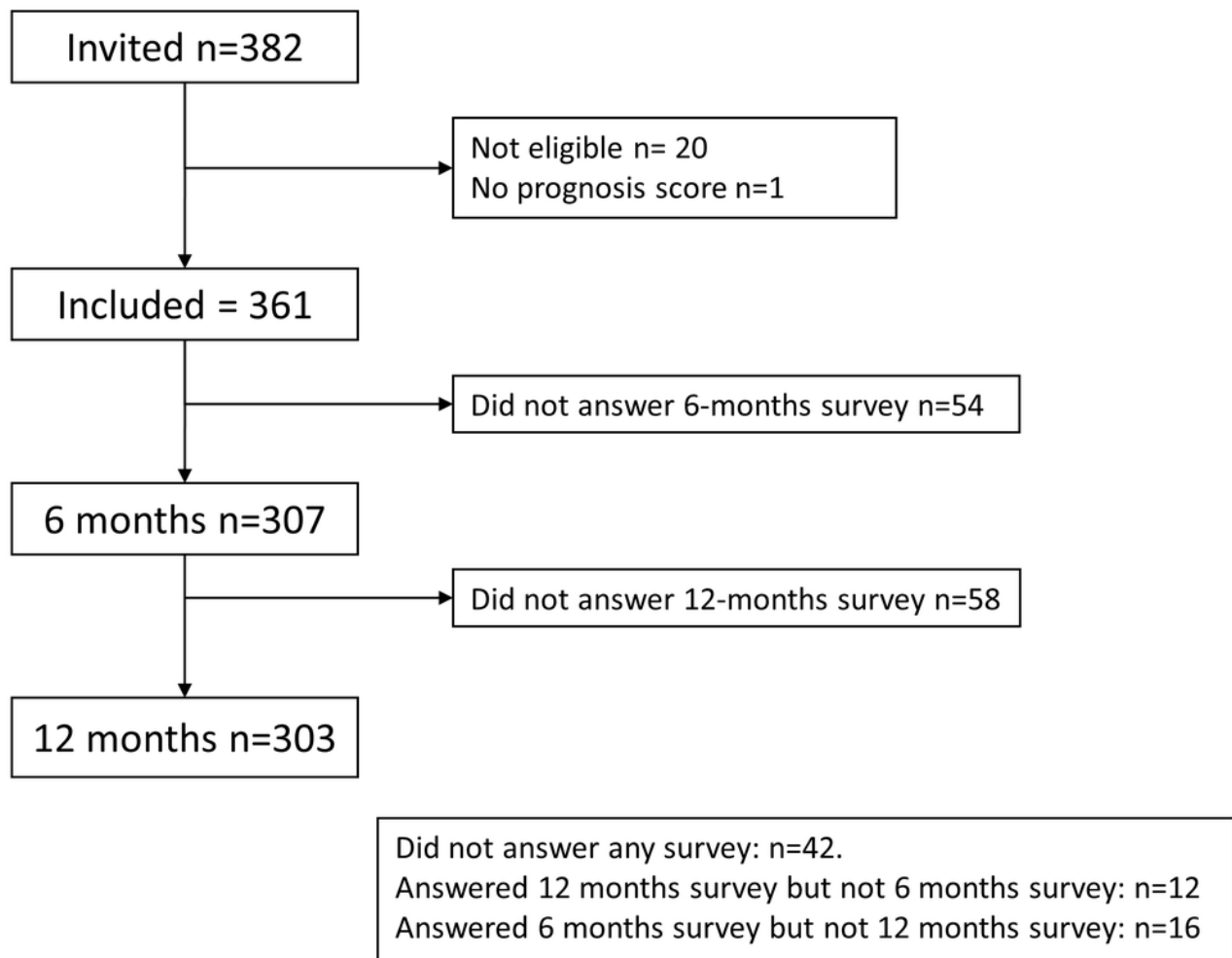
Figure 2

Calibration plots for PASS and Treatment Success at 6 and 12 months.

Predicted probability of achieving either PASS or Treatment Success is given on the x-axis, and the observed probability is given on the y-axis. The dashed diagonal line represents perfect agreement between the predicted and actual probability of PASS or Treatment Success. The dots represent the physiotherapists prognostic scores. Error bars are 95% confidence intervals. At the x-axis, the distribution of the predicted probabilities is shown.