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# Feasibility of a multimodal prehabilitation program before elective knee and hip arthroplasty in older adults

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# 1 **ABSTRACT**

## 2 **Objectives**

3 Hip osteoarthritis and knee osteoarthritis cause significant disability and pain in older adults,  
4 often leading to hip or knee replacement surgery. Prehabilitation programs have been  
5 established for these surgeries, but there are few programs for orthogeriatrics. We evaluated the  
6 feasibility of a new multimodal prehabilitation program (MPP) for older adults before hip or  
7 knee replacement due to arthrosis: the Prehabilitation for Os (PRE4OS) study.

## 8 **Design**

9 We conducted a multicenter feasibility study in the Greater Paris area.

## 10 **Setting and Participants**

11 Adults  $\geq 75$  years old awaiting hip or knee replacement with at least a 6-week delay before  
12 surgery and able to participate in MPP follow-up were eligible. The MPP included weekly  
13 hospital sessions providing nutritional, psychological, functional, and cognitive support, along  
14 with weekly home sessions featuring physiotherapist visits.

## 15 **Methods**

16 The primary outcome was at least 80% of one-day hospital (ODH) sessions performed by 80%  
17 of participants. Secondary outcomes included intervention achievement, quality of life, and  
18 nutritional and functional status changes. Participant's satisfaction was qualitatively assessed  
19 via structured phone interviews pre-surgery and at 30 days post-surgery.

## 20 **Results**

21 From September 2021 to September 2023, 27 individuals participated in the PRE4OS study.  
22 The mean (SD) age was 83 (4.3) years, with 7 males (26%) and median baseline Activities of  
23 Daily Living score 5.5 (interquartile range 5.5-6.0). Surgeries were hip prostheses for 17

24 participants (63%) and knee prostheses for 10 (37%). The primary outcome was achieved in  
25 89% of participants, with comparable rates for hip and knee prostheses. In total, 60% of  
26 participants rated the MPP as "excellent" pre-surgery and 100% at 30 days post-surgery  
27 expressing a willingness to recommend the protocol to a friend or family.

## 28 **Conclusion and Implications**

29 The MPP was feasible for individuals before hip or knee replacement and was well received.  
30 Further randomized trials are needed to assess its clinical impact.

31

32

## 33 INTRODUCTION

34 Arthrosis is a prevalent condition among older adults, affecting more than 10 million  
35 individuals in France and approximately 80% of French patients over age 80.<sup>1</sup> Globally, it is  
36 projected to affect more than a billion people by 2050.<sup>2</sup> Knee and hip osteoarthritis are among  
37 the three most common forms of arthrosis, with knee osteoarthritis the most prevalent in  
38 Europe.<sup>2</sup> At the same time, in France during the last 20 years, the rate of prosthesis insertion  
39 for individuals > 85 years old has doubled for hip osteoarthritis and tripled for knee  
40 osteoarthritis.<sup>3</sup> Nevertheless, older adults face a heightened risk of post-operative  
41 complications, rehospitalization, and mortality.<sup>4</sup> The severity of these risks can be attributed to  
42 1) preoperative frailty<sup>5,6</sup>, 2) preoperative multimorbidity, and 3) increased risk of hospital-  
43 associated disability in older adults.<sup>7</sup>

44 Concerning these risks for older adults, orthogeriatrics has significantly expanded in  
45 recent years, using and integrating various care models.<sup>8</sup> First, orthogeriatric care pathways,  
46 including Units for Peri-Operative Geriatric care (UPOG), have been established primarily for  
47 emergency trauma surgery. Second, perioperative geriatric teams, providing guidance to  
48 surgeons and orthopedic healthcare professionals in their units, have been developed for  
49 patients admitted for elective surgery or for those not eligible for hospitalization in UPOG.  
50 Early rehabilitation programs have also been developed<sup>9-11</sup>, but data on preoperative  
51 interventions for elective surgery are still lacking.

52 Prehabilitation programs have been developed, particularly for cardiac (transcatheter  
53 aortic valve implantation)<sup>12</sup> and oncologic surgery (colon cancer)<sup>13</sup>. These programs have  
54 demonstrated benefits for preoperative nutritional and functional status (muscular,  
55 cardiopulmonary, psychological), albeit with less certainty regarding postoperative  
56 benefits.<sup>13,14</sup> As for the field of hip and knee prostheses, the studies remain relatively few<sup>4,15</sup>  
57 and mostly focus on unimodal interventions. Yet, there is indeed a real need for multimodal

58 programs that provide more comprehensive and holistic care (including not only physical health  
59 but also nutritional and mental well-being)<sup>16</sup>, despite the potential for increased costs (requiring  
60 more staff and technical resources)<sup>17,18</sup> and reduced acceptability (the intervention might be too  
61 complex physically and cognitively). All these facts underscore the need for standardized and  
62 multimodal programs for hip or knee prosthesis projects in people with arthrosis.

63 In this setting, we initiated a multicenter multimodal prehabilitation program (MPP) in  
64 the greater Paris area, targeting older adults ( $\geq 75$  years old) awaiting hip or knee prosthesis for  
65 arthrosis. The objective of this study was to assess the feasibility of implementing this MPP.

66

## 67 **METHODS**

68           This study received approval from the Comité de Protection des Personnes Ouest II -  
69 Angers in Angers (protocol no.: 21.02.03.61946 [2021/22], April 14, 2021). All interventions  
70 adhered to the 2013 version of the Helsinki Declaration. Data collection and storage were  
71 conducted in accordance with the MR-001 guidelines of the Conseil National Informatique and  
72 Liberté (National Commission for Information Technology and Civil Liberties). Written  
73 consent was obtained from participants before their inclusion in the study and participation in  
74 the MPP. A safety analysis of potential adverse events collected during one-day hospital (ODH)  
75 sessions, home sessions, and follow-up phone calls was planned.

76           The study adheres to the CONSORT Guidelines for pilot or feasibility studies  
77 (*Supplemental Table S1*).

78

### 79 *Study design*

80           The study was a multicenter interventional feasibility study conducted in 5 hospitals in the  
81 Greater Paris area: Pitié-Salpêtrière Hospital in Paris, Saint-Antoine Hospital in Paris,  
82 Lariboisière Hospital in Paris, Richaud Hospital in Versailles, and Sud-Francilien Hospital in  
83 Corbeil-Essonnes. Because of recruitment challenges, the intervention spanned 2 years. After  
84 enrollment, participants were monitored for 6 weeks before surgery and 30 days post-surgery.  
85           The program consisted of weekly ODH sessions and weekly physiotherapist home visits over  
86 6 weeks (*Figure 1*). The program was developed in consultation with members of the OLD'UP  
87 association (older individuals), with the goal of delivering interventions that are as acceptable  
88 as possible in terms of content, frequency, and intensity.

89           A physician (BG) conducted weekly phone calls with each participant to gather  
90 feedback on their experiences and satisfaction, both before their first ODH session and after

91 their final ODH session. These calls also involved assessing any adverse events and pain via a  
92 structured interview.

93 At 1 month post-surgery, a clinical study technician (CC) conducted another structured  
94 phone interview to review the participants' vital status, any instances of rehospitalization, and  
95 their long-term satisfaction after the intervention and surgery.

96

### 97 *Sample selection*

98 The surgeons were briefed on the study protocol and objectives. Individuals were  
99 initially assessed by orthopedic surgeons during their first visit for hip or knee osteoarthritis,  
100 when they were screened for the study inclusion criteria. Following this screening, a local  
101 geriatrician contact was notified, who then reached out to the investigative team. The  
102 geriatrician then contacted the patient to verify the inclusion criteria which comprised age  $\geq 75$   
103 years and surgical indication for knee or hip prosthesis because of arthrosis. Exclusion criteria  
104 were also checked at this moment: 1) surgical delay of less than 6 weeks, 2) physical and  
105 cognitive inability to participate in the MPP, 3) living far from the prehabilitation center and 4)  
106 none health insurance coverage. Patients were then enrolled after reading and comprehending  
107 the information notice and providing written consent.

108

### 109 *Intervention (Figure 1)*

110 The MPP spanned 6 weeks and involved a combination of hospital and home  
111 interventions. Included individuals underwent a geriatric assessment with the Comprehensive  
112 Geriatric Assessment as recommended, which entailed evaluating medical history, current  
113 treatments, autonomy, functional status, frailty, nutritional status, and cognitive function.<sup>19</sup> This  
114 assessment facilitated the customization of the MPP and the planning of interventions tailored  
115 to each participant's needs.



116

117 *Hospital intervention (ODH)*

118 The ODH sessions took place once a week over 6 weeks (ODH 1 = first ODH, ODH 6 = sixth  
119 ODH). Each intervention was the result of several meetings between the investigators and the  
120 nurses, dietitians, psychologists, and physiotherapists involved in the PRE4OS study. These  
121 sessions comprised a multimodal program of the following:

- 122 1) Dietetic intervention: A 20-30 min dietary assessment delivered at ODH1, followed by  
123 recommendations based on French<sup>20</sup> and US<sup>21</sup> peri-operative recommendations. A  
124 reevaluation was performed at ODH3 and 6.
- 125 2) Psychological intervention: A 20- to 30-min psychological evaluation focused on  
126 participant expectations and fears about surgery that included passive listening inspired  
127 by Carl Rogers Client Centered Psychotherapy<sup>22</sup> and quantification of anxiety, pain,  
128 happiness and pleasure. Sessions occurred every weeks during 6 weeks.
- 129 3) Functional intervention: Two 20-min sessions of balance and gait training and muscular  
130 strengthening of lower limbs by physiotherapists and one 40-min functional session  
131 based on a exergame designed by Genius Healthcare.<sup>23</sup> This exergame is an innovative  
132 digital medical device for neuropsychiatric diseases developed after 2011. It is a video  
133 game based on motion capture via Kinect, in which individuals control an avatar by  
134 performing rapid, wide-range movements with their 4 limbs, combined with lateral and  
135 vertical movements of the pelvis and trunk, movements suitable for the rehabilitation of  
136 gait and balance disorders (CE marking: 93/42/CEE).
- 137 4) Cognitive intervention: Two 10- to 15-min sessions of cognitive exercises (cognitive  
138 games without functional exercise on a digital tablet developed for individuals with  
139 neurocognitive disease by Genius Healthcare<sup>23</sup>).

140 5) “Empowering” intervention: Two 10-min empowerment sessions were based on  
141 resources developed for the MPP. These sessions included 10 videos covering topics  
142 such as hip and knee prosthesis surgery, anesthesia, post-operative complications, post-  
143 operative delirium, undernutrition, potential therapeutic adjustments after surgery, and  
144 functional rehabilitation with post-surgery exercises. After watching each video, the  
145 participant could speak directly with the ODH nurse during a dedicated time or  
146 informally with the other rehabilitators participating in the program.

147

#### 148 *Home intervention*

149 The 1-hr home intervention program was conducted by a physiotherapist once a week. These  
150 sessions followed a standardized format and included the following:

- 151 1) Warm up exercises for joints and major muscle groups
- 152 2) Exercises targeting static/dynamic balance training, gait training (home or outdoor  
153 exercises), and muscular strengthening of lower limbs, abdominal, and back muscles
- 154 3) Stretching and relaxation exercises
- 155 4) Assessment of patient participation and satisfaction

156 Between two ODH sessions, participants could also freely perform cognitive exergames at  
157 home using a digital tablet provided by Genious Healthcare.

158

#### 159 *Outcomes*

160 Our primary outcome was achievement of at least 80% of ODH sessions by at least 80%  
161 of participants. The 80% value for this criterion was the result of a literature review and  
162 opinions of a panel of experts including geriatricians, patients, physiotherapists, psychologists  
163 and dieticians. Every healthcare worker collected patient participation in an MPP Passport  
164 during every ODH and home session.

165 Secondary quantitative criteria included 1) achievement of ODH and home sessions in  
166 3 categories (>80%, 50-80%, and <50%); 2) quality of life measured by the EuroQol 5-  
167 dimensions 3-levels (EQ-5D-3L)<sup>24</sup> and Medical Outcomes Study 36-item short form (SF-36)<sup>25</sup>  
168 at ODH1, 3 and 6; 3) pain assessed by a visual analog scale (0 to 10)<sup>26</sup> at the conclusion of  
169 every ODH physiotherapist session; 4) nutritional status evaluated by changes in weight during  
170 the program, dietary habits, and daily water/protein consumption; 5) mobility assessed by the  
171 Short Physical Performance Battery (SPPB)<sup>27,28</sup> at ODH1 and 6; and 6) anxiety level measured  
172 at the beginning and during the MPP by the SF-36 and a visual analog scale at ODH1 and 6.

173 Adverse events such as death, rehospitalization, and length of stay in rehabilitation and  
174 acute care units were also recorded 30 days post-operatively.

175 Secondary qualitative criteria were 1) participant satisfaction measured by  
176 questionnaires (developed by the entire investigative team and evaluated by a psychologist  
177 expert in qualitative research) at admission to and discharge from the MPP (phone call) and 2)  
178 satisfaction follow-up at 30 days.

179 Data were collected prospectively by BG, MN and CC. Demographic, nutritional,  
180 functional, and cognitive characteristics and medical history with treatments were collected at  
181 the first hospital visit, during the Comprehensive Geriatric Assessment. The physiotherapists  
182 performing home sessions collected data (exercises performed, pain score, and satisfaction)  
183 during these sessions. All other data were collected during phone calls with BG, MN or CC or  
184 during ODH sessions

185

### 186 *Sample size calculation*

187 We did not have a sample size calculation because our study was a feasibility study  
188 without randomized or allocated interventions, and all participants received the MPP in a single  
189 group. Given the material constraints (Exergames) and organizational constraints (a maximum

190 of 2 patients recruited simultaneously), as well as the relatively small sample sizes of previous  
191 studies on the subject (between 40 and 80 patients in total), a sample size of 50 patients was set  
192 (10 individuals per center).

193

#### 194 *Statistical and qualitative analysis*

##### 195 *Quantitative analysis (follow-up)*

196 Quantitative analysis involved describing participants' baseline characteristics, medical  
197 history, baseline treatments, Geriatric Comprehensive Assessment, and then multimodal data  
198 from their follow-up. Categorical variables were described with number (percentage) and  
199 quantitative variables with mean (SD) or median (interquartile range) if the distribution was not  
200 normal or not continuous.

201 Baseline characteristics, medical history, treatments, multimodal follow-up during the  
202 program and follow-up after surgery were compared between individuals expecting knee and  
203 hip prostheses. Statistical tests were used to compare only 4 of the secondary outcomes between  
204 baseline (ODH1) and the end of the MPP (ODH6): EQ-5D-3L, SPPB, SF-36 (all categories),  
205 and weight.

206 We decided to avoid inflating the alpha risk in this very small sample. We used paired  
207 Student *t* or Wilcoxon-Mann-Whitney test to compare outcomes. The alpha risk was defined  
208 bilaterally at 5%, and statistical analyses involved using R-Studio v2023.06.0+421.

209

##### 210 *Qualitative analysis (questionnaires)*

211 For the phone-call questionnaires administered at the beginning (before ODH1) and end  
212 of the MPP (after ODH1 and before surgery) and 30 days post-operatively, the data are  
213 described with percentages because the questions were close-ended.

## 214 **RESULTS**

215           Between September 2021 and September 2023, 46 individuals were screened and 27  
216 were finally included in PRE4OS study. The flow of individuals in the study is in *Figure 2*.  
217 Their mean age was 83 (4.3) years and 7 (26%) were men (*Table 1*). At baseline, the median  
218 ADL was 5.5 (5.5-6.0) and median SPPB score 8.0 (6.0-10) (*Table 1*). Ten individuals (37%)  
219 were expecting a knee prosthesis for knee osteoarthritis and 17 (63%) a hip prosthesis for hip  
220 osteoarthritis.

221           As compared with individuals with hip osteoarthritis, those with knee osteoarthritis  
222 seemed less socially isolated at home (30% vs. 53%) and younger (mean age 82 vs. 84 years),  
223 had higher cardiovascular risk (diabetes, hypertension and overweight), and were less  
224 frequently depressed (10% vs. 47%) (*Table 1*).

225

### 226 *Primary outcome: global feasibility of ODH sessions (Table 2)*

227 Overall, 89% of individuals participating in the MPP completed more than 80% of the ODH  
228 sessions. The median number of completed ODH sessions for all groups was 6 (5-6), and only  
229 one individual (4%) attended less than 50% of the ODH sessions.

230

### 231 *Feasibility of every intervention (Table 2)*

232 Regarding each intervention separately, 78% of participants completed 80% of home sessions.  
233 ODH functional, dietary, psychological, and empowerment sessions were well received by  
234 participants. ODH exergame and cognitive sessions were less accepted, with a median of 5/6  
235 sessions (3-6) and 4/6 sessions (1-5).

236 ***Follow-up during the MPP and after surgery (Table 3 and Supplemental Figure S2)***

237           During the study, participants gained a mean of 0.58 (1.54) kg between ODH1 and 6,  
238 although not significantly (P= 0.10).

239           For psychologic follow-up, 2 dimensions were noted: 1) mean change in EQ-5D-3L  
240 score of +0.08 (0.24) between ODH1 and 6, although not significant (P = 0.16), and a 2) mean  
241 change in physical functioning of +5.31 (9.91) on the SF-36 between ODH1 and 6 (P <0.05).  
242 Additionally, EQ-5D-3L scores increased between ODH1 and 3 and then remained stable, with  
243 better results in participants awaiting hip than knee prosthesis (*Supplemental Figure S1*).

244           Regarding functional outcomes, median SPPB score differed between ODH1 and 6  
245 although not significantly (P = 0.06), showing an increase of 1 point (0-2). Also, SPPB score at  
246 ODH6 was better for individuals expecting a hip than knee prosthesis, which was contrary to  
247 the situation at baseline (*Supplemental Figure S1*).

248

249 ***Satisfaction and pain (Table 3, Supplemental Table S2 and Figure S2)***

250           Regarding satisfaction after ODH6, 60% of participants rated the MPP as "excellent,"  
251 8% "good," and 32% "suitable." Additionally, 84% reported being "very satisfied" with home  
252 sessions. The number of ODH sessions per week was considered "perfect" by 100% of  
253 participants, the duration of ODH sessions "well adapted" by 92%, and the overall program  
254 duration "well adapted" by 84%. At 30 days post-surgery, 100% of participants stated that they  
255 "Would recommend this protocol to someone they know," and 80% indicated that they strongly  
256 totally or quite agreed that the program "better prepared them for their operation."

257           More details about pain management, recovery from walking and anxiety are  
258 respectively provided in *Supplemental Figure S2 and Table 3. Supplemental Figure S2*

259 illustrates that among 23 participants (4 with missing values for all ODH sessions), 14 (61%)  
260 had stable or decreasing pain levels during all ODH functional sessions. For participants who  
261 experienced an increase in pain at ODH6 versus ODH1, two profiles emerged: 1) discrete pain  
262 decrease and increase between ODH5 and 6 (3 participants), and 2) continuous pain increase  
263 from ODH1 to 6 (4 participants).

## 264 **DISCUSSION**

265         The MPP we developed represents the first prehabilitation program in orthogeriatrics  
266 with a holistic approach, addressing functional, nutritional, psychological, and cognitive  
267 aspects simultaneously, with the goal of empowering older individuals. In this initial  
268 multicenter feasibility study, the program was highly feasible, with 89% of participants  
269 completing more than 80% of the sessions. Furthermore, it was well received by participants,  
270 with 60% rating the MPP as "excellent".

271         In previous meta-analyses and systematic reviews of prehabilitation for knee<sup>29-31</sup> or hip  
272 prosthesis<sup>32</sup>, most studies primarily offered exercises, with some including education or  
273 teaching programs at best. Our study constitutes the initial phase of a program that integrates  
274 cognitive and functional exercises with the help of a therapist and innovative medical devices  
275 as well as comprehensive dietary monitoring. It also introduces new psychological follow-up  
276 methods based on Carl Rogers' passive listening, focusing on patient expectations and fears,  
277 and empowerment sessions with videos explaining the risks and complications of surgery and  
278 future orthogeriatric pathways.

279         Previous programs<sup>29,30</sup> typically focused on exercises targeting one or two types of  
280 functions, often led by a hospital or home practitioner, and did not involve the use of real-life  
281 situations or video simulators.

282         This MPP is innovative in its home intervention approach, involving 1 hr per week with  
283 a home physiotherapist. Previous programs typically offered telerehabilitation<sup>33</sup>, group

284 sessions<sup>34</sup>, or autonomous home exercises<sup>31</sup>, with physiotherapists often citing limitations such  
285 as short exercise durations and reduced human contact.<sup>35</sup> In particular, concerning the  
286 functional intervention both at home and at the hospital, exercises targeted strength or hip/knee  
287 flexion and extension and also encompassed gait, walking, and static/dynamic balance,  
288 incorporating real-life scenarios (outdoor or home exercises) as well as virtual situations  
289 (exergames). Even though our prehabilitation program was designed similarly for hip and knee  
290 osteoarthritis, a separate analysis was conducted due to clinical and functional differences  
291 between these two groups. While we acknowledge that this division may affect comparability,  
292 this separation was intended to provide a clearer picture of how the MPP performs across  
293 different types of joint replacements and to identify any differential effects that may inform  
294 future, more targeted interventions.

295         Other previous studies have reported relatively good compliance with similar programs  
296 (although less multimodal as compared with our MPP), with a mean duration of 6 weeks.<sup>36,37</sup>  
297 In systematic reviews or meta-analyses<sup>15,29,31</sup>, many previous programs showed greater  
298 variability in session frequency, ranging from 1 to 3 sessions per week to 2 sessions per month.  
299 Despite this, our more complex and higher-frequency program was well received by  
300 participants, as evidenced by 100% considering the number of ODH sessions per week as  
301 "perfect." Hence, this more comprehensive approach (even if it entails a heavier program) rather  
302 than a unimodal one was well accepted by patients.

303         We found a significant improvement in quality of life (secondary outcome) between the  
304 beginning and end of the MPP, as measured by the SF-36 physical function subsection,  
305 particularly notable for individuals awaiting hip prosthesis. Previous studies examining  
306 prehabilitation programs (which were unimodal, focusing solely on functional, psychological,  
307 or educational aspects) in younger orthogeriatric patients also reported similar improvements  
308 for knee<sup>29,38,39</sup> or hip prosthesis recipients.<sup>40</sup> We also found improved physical functioning



309 (not statistically significant probably due to lack of power) measured by the SPPB, which was  
310 previously reported.<sup>29,31,41</sup>

311

### 312 ***Strengths***

313           Because previous interventional studies<sup>29–32,42</sup> involved younger populations (mean age  
314 60.7 to 72.8 years) and often included individuals with obesity (minimum body mass index 30  
315 kg/m<sup>2</sup>), our findings are more applicable to geriatric individuals with advanced age and frailty.  
316 In our sample, participants were relatively older, with mean age 83 (4.3) years, and had a higher  
317 prevalence of polymedication (70%) defined by at least 5 treatments per day. However, they  
318 had preserved autonomy (median ADL 5.5 [5.5-6.0]) and few comorbidities (median Charlson  
319 Comorbidity Index 1.0 [0-2.0]), and none had dementia.

320           Additionally, our study involved multiple centers, encompassing university and non-  
321 university hospitals, which enhances the external validity of our findings. Our program was  
322 developed by a multidisciplinary team comprising experts in each modality, including  
323 orthogeriatric medical physicians, dieticians, physiotherapists, psychologists,  
324 neuropsychologists, and nurses. We also sought the opinions of patients before creating this  
325 protocol, which allowed for optimal consideration of their desires. This extensive collaboration  
326 among healthcare professionals fostered a holistic and multimodal approach to our program,  
327 offering patients a comprehensive intervention.

328

### 329 ***Limitations***

330           One limitation of our study is the recruitment challenges experienced due to the COVID-  
331 19 pandemic in 2021 and 2022 (27 patients for 50 patients initially planned). This shortfall in  
332 recruitment could affect the statistical power and generalizability of the conclusions. However,  
333 once recruited, participants actively participated in and appreciated our program. Additionally,

334 we cannot rule out the possibility of selection bias introduced by orthopedists during  
335 consultations. Furthermore, we recruited only patients residing near the rehabilitation centers,  
336 which may impact the generalizability of our results.

337 Participant satisfaction was assessed using structured questions, which may have limited  
338 the breadth of opinions and experiences. Moreover, we did not collect healthcare professionals'  
339 feedback on the feasibility of and satisfaction with the MPP, which could have provided  
340 valuable insights into potential organizational or technical improvements. To address these  
341 limitations, we plan to complement our results with a qualitative study, involving interviews  
342 with participants and focus groups with caregivers. This approach will enable a deeper  
343 exploration of the obstacles to and facilitators of the implementation of the MPP.

## 344 **CONCLUSION AND IMPLICATIONS**

345 The PRE4OS study suggested that the 6-week multimodal prehabilitation program was well  
346 accepted and appreciated by participants both before and 30 days after surgery. However,  
347 further studies, such as randomized clinical trials, incorporating a medico-economic dimension,  
348 are warranted to evaluate the clinical efficacy of this type of prehabilitation program in  
349 orthogeriatric patients and demonstrate the favorable cost-effectiveness ratio of their  
350 implementation. These studies should assess outcomes related to autonomy as well as  
351 functional, nutritional, psychological, and cognitive status before and after surgery.

352

## 353 **CONFLICT OF INTEREST**

354 None declared.

355

## 356 **AUTHORS' CONTRIBUTION**

357 BG: protocol redaction, center coordination, participant recruitment and data collection, data  
358 analysis and interpretation, manuscript redaction

359 LZ: protocol redaction, supervision of analysis and results proofreading, manuscript editing

360 JB: principal investigator, protocol redaction, results proofreading

361 DBZ: methodological referent, results proofreading

362 JCB, CN, DOH, VF: participant inclusion and follow-up at hospital during the program,  
363 results proofreading

364 CC: protocol editing, center coordination, data collection

365 AC: protocol editing, center coordination, methodological referent

366 CD: protocol editing, center coordination

367 MN: participant recruitment and data collection

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512 **LEGENDS**

513 **Figure 1:** Participant inclusion and follow-up during the multimodal prehabilitation program  
514 (MPP)

515 **Figure 2:** Flow of participants in the study

516 **Table 1:** Characteristics of participants by prosthesis type

517 **Table 2:** Feasibility and acceptability of PRE4OS study according to prosthesis type

518 **Table 3:** Follow-up of participants by prosthesis type

519 **Supplementary Figure S1:** Change in EuroQol 5-dimensions 3-levels (EQ-5D-3L) and Short  
520 Physical Performance Battery (SPPB) scores (at weeks 1, 3 and 6) by prosthesis type

521 **Supplementary Figure S2:** Change in pain score during functional one-day hospital (ODH)  
522 sessions

523 **Supplementary Table S1:** CONSORT guidelines for pilot or feasibility study (2010)

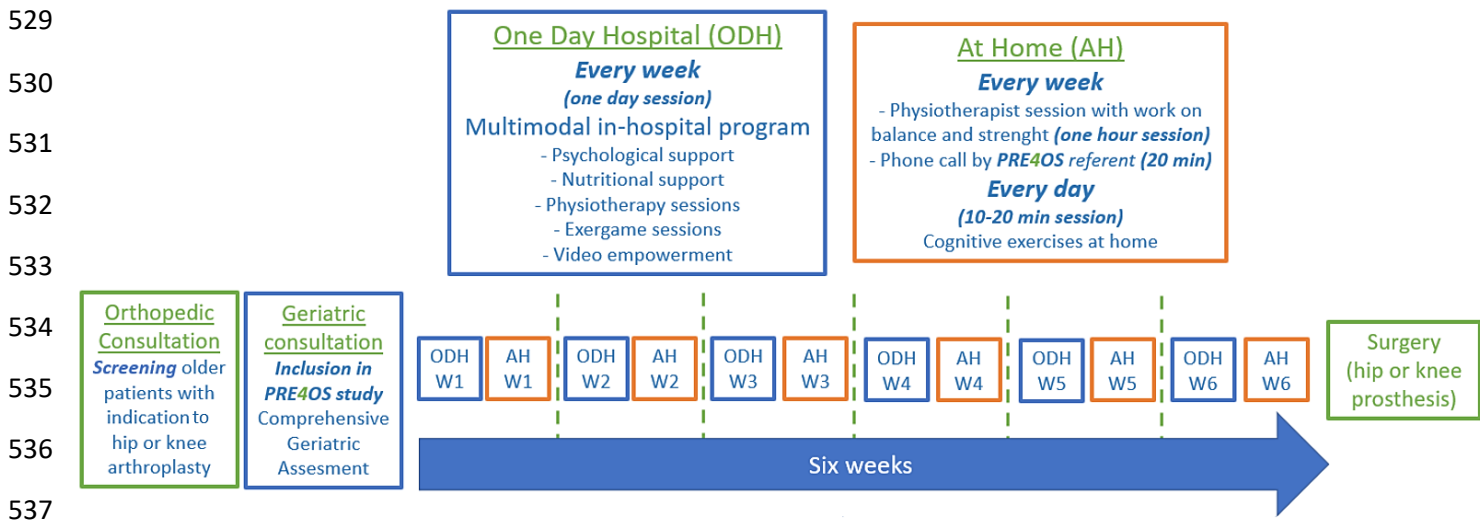
524 **Supplementary Table S2:** Satisfaction by prosthesis type (25 participants)

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526 **Figures and Tables**

527 **Figure 1. Participant inclusion and follow-up during the multimodal prehabilitation**  
528 **program (MPP)**



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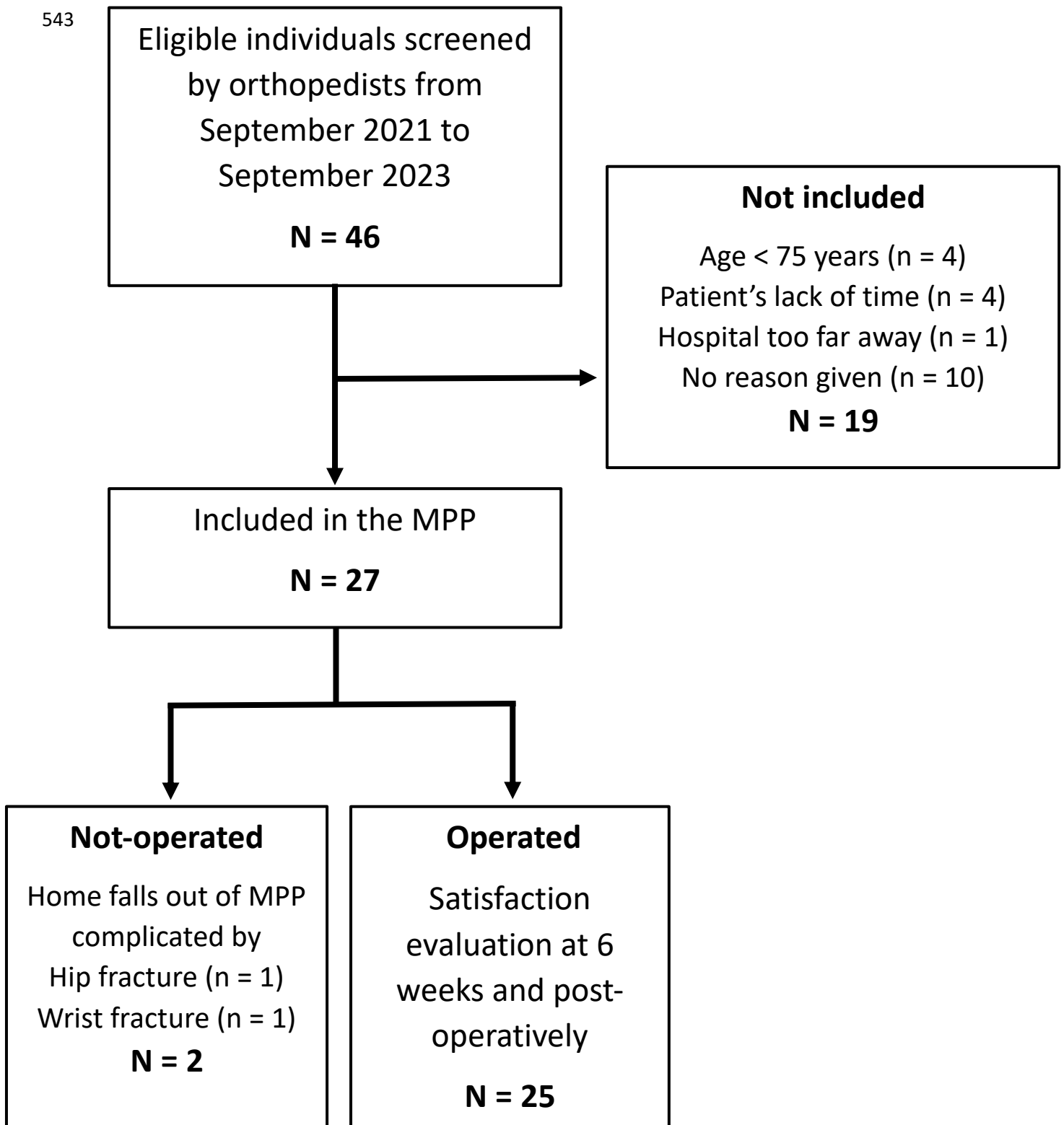
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541 *Figure 2. Flow of participants in the study.* MPP, multimodal prehabilitation program

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**Table 1: Characteristics of participants by prosthesis type**

	<b>All patients N = 27</b>	<b>Knee prosthesis N = 10</b>	<b>Hip prosthesis N = 17</b>
Age (years), mean (SD)	83 (4.3)	82 (4.0)	84 (4.4)
<85	15 (56)	7 (70)	8 (47)
85 to 90	12 (44)	3 (30)	9 (53)
>90	0 (0)	0 (0)	0 (0)
Male	7 (26)	3 (30)	4 (24)
Living alone at home	12 (44)	3 (30)	9 (53)
Assistance at home			
Nurse	3 (11)	0 (0)	3 (18)
Physiotherapist	4 (15)	1 (10)	3 (18)
Caregiver	7 (26)	3 (30)	4 (24)
Education level			
University	3 (11)	2 (20)	1 (5.9)
High school	5 (19)	1 (10)	4 (24)
Middle school	5 (19)	2 (20)	3 (18)
Primary	5 (19)	4 (40)	1 (5.9)
Missing	9 (33)	1 (10)	8 (47)
<b>Medical history</b>			
Alcohol use	5 (19)	1 (10)	4 (24)
Charlson Comorbidity Index, median (IQR)	1.0 (0-2.0)	1.0 (1.0-2.0)	0 (0-2.0)
Neurologic and psychiatric diseases			
Dementia	0 (0)	0 (0)	0 (0)
Parkinson disease	0 (0)	0 (0)	0 (0)
Ischemic stroke	1 (3.7)	0 (0)	1 (5.9)
Anxiety	4 (15)	1 (10)	3 (18)
Depression*	9 (33)	1 (10)	8 (47)
Cardiovascular diseases			
Hypertension	16 (59)	10 (100)	6 (35)
Coronary artery disease	4 (15)	1 (10)	3 (18)
Cardiac failure	2 (7.4)	0 (0)	2 (12)
Rythm or conduction disease	5 (19)	1 (10)	4 (24)
Thromboembolic disease	2 (7.4)	0 (0)	2 (12)
Lower extremity artery disease	1 (3.7)	1 (10)	0 (0)
Endocrinologic diseases			
Diabetes	7 (26)	6 (60)	1 (5.9)
Dysthyroidism	8 (30)	2 (20)	6 (35)
Chronic renal disease <sup>†</sup>	4 (15)	2 (20)	2 (12)
Orthopedic and rheumatologic diseases			
Osteoporosis	2 (7.4)	0 (0)	2 (12)
Lower or Upper limb fracture	8 (30)	1 (10)	7 (41)
Number of drugs per day, median (IQR)	6.0 (5.0-7.0)	6.0 (6.0-7.0)	5.0 (4.0-6.0)
Polymedication <sup>‡</sup>	19 (70)	8 (80)	11 (65)

546 **Table 1: Characteristics of participants by prosthesis type (follow-up)**

Nutritional status			
Weight (kg), mean (SD)	69 (12)	73 (11)	67 (13)
BMI (kg/m <sup>2</sup> ), mean (SD)	28 (4.7)	30 (4.5)	26 (4.2)
Mini Nutritional Assessment score, median (IQR)	26 (24-28)	24 (24-26)	27 (24-29)
Undernutrition <sup>§</sup>	1 (4.0)	0 (0)	1 (6.0)
Functional status and Quality of life			
ADL, median (IQR)	5.5 (5.5-6.0)	5.5 (5.5-6.0)	6.0 (5.0-6.0)
Short-iADL, median (IQR) <sup>  </sup>	4.0 (3.0-4.0)	4.0 (3.0-4.0)	4.0 (3.0-4.0)
EQ-5D-3L, mean (SD)	0.51 (0.33)	0.47 (0.28)	0.54 (0.36)
Oxford Knee Score, median (IQR)	37 (34-40)	37 (34-40)	-
Oxford Hip Score, median (IQR)	35 (29-41)	-	35 (29-41)
SPPB score, median (IQR)	8.0 (6.0-10)	9.0 (6.0-10)	8.0 (6.0-9.0)
Still driving car	6 (22)	3 (30)	3 (18)
Walk outside	22 (82)	10 (100)	12 (71)
Walk inside			
Without help	17 (63)	6 (60)	11 (65)
With mechanic help	9 (33)	4 (40)	5 (29)

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549 Data are n (%) unless otherwise indicated.

550 \*Current or resolved

551 †Defined as an eGFR<60 ml.min-1 (Cockcroft & Gault)

552 ‡Defined by at least 5 treatments/day

553 §According to HAS definition of 2007

554 ||Short form of iADL including four items (Managing Finance, Managing Medications, Using telephone, Managing transportation).

556 ADL, Activities Daily Living (Katz); iADL, instrumental Activities Daily Living (4 items); BMI, Body Mass Index EQ-5D-

557 3L,EuroQol 5-dimensions 3-levels; SPPB, Short Physical Performance Battery.

558 **Table 2: Feasibility and acceptability of the program by prosthesis type**

	All patients N = 27	Knee prosthesis N = 10	Hip prosthesis N = 17
<b>Primary outcome</b>			
Performed ODH sessions (total = 6), median (IQR)	6 (5-6)	6 (5-6)	6 (5-6)
<50%	1 (4)	0 (0)	1 (6)
50-80%	2 (7)	1 (10)	1 (6)
>80%	24 (89)	9 (90)	15 (88)
<b>Secondary outcomes</b>			
Performed home sessions (total = 6), median (IQR)	6 (6-6)	6 (6-6)	6 (6-6)
<50%	0 (0)	0 (0)	0 (0)
50-80%	2 (7)	1 (10)	1 (6)
>80%	21 (78)	7.0 (70)	14 (82)
<i>Missing data</i>	4 (15)	2 (20)	2 (11)
Performed ODH functional sessions (total = 6), median (IQR)	6 (5-6)	6 (5-6)	6 (5-6)
With > 50% of exercises performed	6 (5-6)	6 (5-6)	5 (5-6)
Performed ODH exergame sessions* (total = 6), median (IQR)	5 (3-6)	6 (5-6)	5 (3-6)
Performed ODH dietary sessions (total = 3), median (IQR)	3 (3-3)	3 (3-3)	3 (2-3)
Performed ODH psychologic sessions (total = 6), median (IQR)	6 (5-6)	6 (6-6)	6 (5-6)
Performed ODH cognitive sessions (total = 6), median (IQR)	4 (1-5)	5 (5-6)	3 (1-5)
Performed ODH empowerment sessions† (total = 10), median (IQR)	10 (9-10)	10 (9-10)	10 (9-10)

559 Data are n (%) unless otherwise indicated.  
 560 \*exergame sessions: 40-min session with a video game based on motion capture  
 561 †empowerment sessions: two 10-min videos during one ODH session explaining post-operative complications and key concepts  
 562 of surgery  
 563 ODH, one-day hospital; IQR, interquartile range  
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**Table 3: Follow-up of participants by prosthesis type**

	<b>All patients N = 27</b>	<b>Knee prosthesis N = 10</b>	<b>Hip prosthesis N = 17</b>
<b>Nutritional follow-up</b>			
Weight difference (kg) <sub>ODH1-6</sub> , mean (SD)	0.58 (1.54) *	0.09 (1.14)	0.95 (1.75)
Daily protein consumption difference (g/d) <sub>ODH1-6</sub> , mean (SD)	-0.03 (0.27)	0.08 (0.13)	-0.09 (0.31)
Daily water consumption difference (l/d) <sub>ODH1-6</sub> , mean (SD)	-0.20 (0.62)	-0.24 (0.87)	-0.17 (0.38)
<b>Psychologic follow-up</b>			
EQ-5D-3L difference <sub>ODH1-6</sub> , mean (SD)	0.08 (0.24) †	0.02 (0.27)	0.12 (0.22)
SF-36 difference <sub>ODH1-6</sub> , mean (SD)			
Physical functioning	5.31 (9.91) ‡	-6.25 (6.30)	9.17 (7.64)
Role limitations due to physical health	-6.25 (23.7)	-18.8 (23.9)	-2.08 (22.5)
Role limitations due to emotional problems	0.02 (21.1)	-16.7 (33.3)	5.58 (13.0)
Energy/fatigue	-2.50 (16.9)	-3.75 (14.4)	-2.08 (0.13)
Emotional well-being	2.25 (24.0)	-2.00 (10.1)	3.67 (27.4)
Social functioning	-2.34 (10.5)	-3.25 (6.50)	-2.04 (11.8)
Pain	2.84 (0.27)	-6.25 (14.9)	5.88 (16.4)
General health	2.50 (18.3)	-8.75 (9.46)	6.25 (19.3)
Health change	11.0 (34.1)	-12.5 (25.0)	18.8 (34.0)
<b>Functional follow-up</b>			
SPPB difference <sub>ODH1-6</sub> , median (IQR)	1 (0-2) §	0 (0-1)	2 (0-2)
Balance test	0 (0-1)	0 (0-0)	0 (0-1)
Gait speed test	0 (0-0)	0 (0-0)	0 (0-1)
Chair stand test	0 (0-2)	0 (0-0)	1 (0-2)
<b>Post-operative follow-up</b>			
LOS in acute unit (days), median (IQR)	7.0 (5.0-10)	6.0 (5.0-8.0)	8.0 (5.0-10)
LOS in rehabilitation unit (days), median (IQR)	25 (7.5-36)	30 (13-49)	23 (5.0-60)
Death at 30 days	0 (0)	0 (0)	0 (0)
Rehospitalization at 30 days	1 (0)	0 (0)	1 (6.0)

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568 \*Paired t-test between weight at baseline and at the end, P = 0.10

569 †Paired t-test between EQ-5D-3L score at baseline and at the end of the program, P = 0.16

570 ‡Paired t-test between SF-36 score baseline and the end of the program, P &lt; 0.05

571 §Wilcoxon paired test between SPPB score at baseline and at the end of the program, P = 0.06

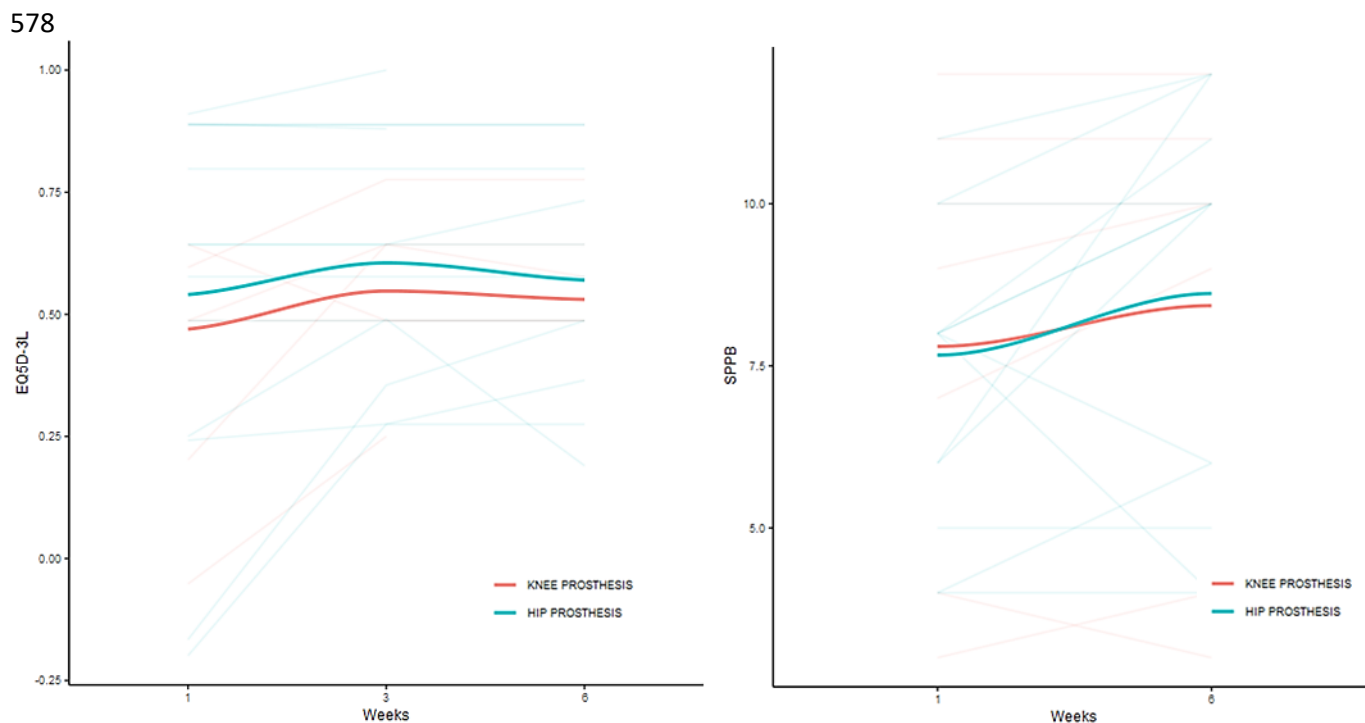
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573 LOS, length of rehabilitation stay; ODH1-6, first to last one-day hospital session; SPPB, Short Physical Performance Battery;

574 EQ-5D-3L, EuroQol 5-dimensions 3-levels; SF-36, Medical Outcomes Study 36-item short form

575

576 **Supplementary Figure S1: Change in EuroQol 5-dimensions 3-levels (EQ-5D-3L)**  
577 **and Short Physical Performance Battery (SPPB) scores by prosthesis type**



590

591 EQ5D was measured at weeks 1, 3 and 6. SPPB was measured only at weeks 1 and 6.

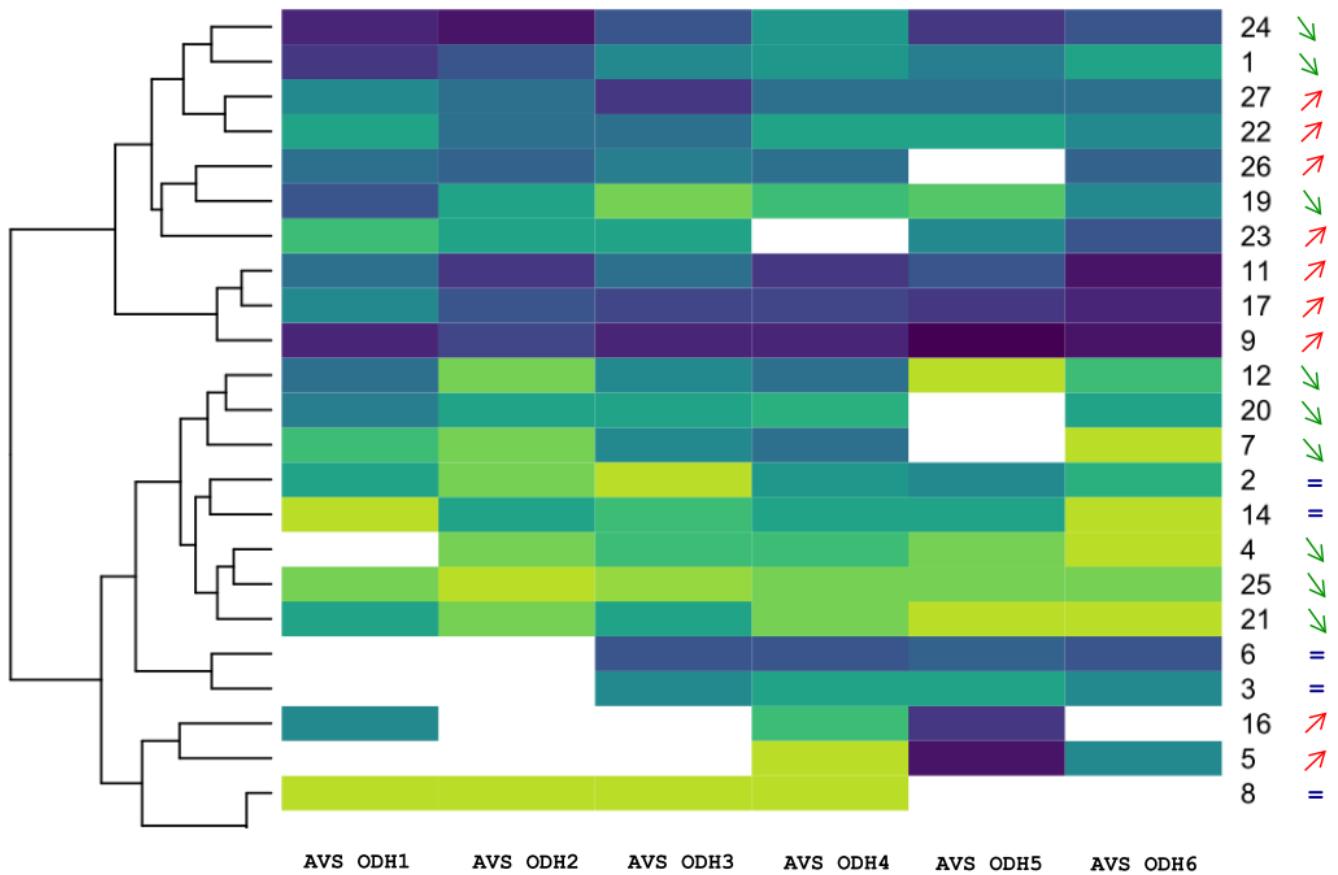
592

593 Solid line: mean of the hip prosthesis group or knee prosthesis group

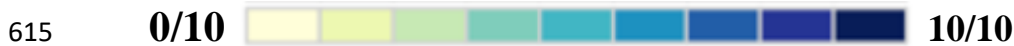
594 Thin line: score progression for each patient

595

596 **Supplementary Figure S2: Change in pain score during functional one-day**  
 597 **hospital (ODH) sessions**



614



616

617

618 ↗ Increasing pain between ODH6 and 1

619 ↘ Decreasing pain between ODH6 and 1

620 = Stable pain between ODH6 and 1

621

622 Data are mean pain score on a visual analog scale (0 = no pain, 10 = maximal pain) evaluated by patient at the end of every

623 ODH functional session (ODH1 to 6).

624 The variations were described by the difference in pain score between the ODH1 and 6, with a visually graded variation in

625 color between the 2 sessions. No specific model or statistical test was used.

626 Missing values for all ODH sessions for 4 patients. If a value was missing for an ODH session, the color is white.

627

628

629



**Supplementary Table S1: CONSORT Guidelines for pilot or feasibility study (2010)**

Section/Topic	Item No	Checklist item	Reported on page No
<b>Title and abstract</b>			
	1a	Identification as a pilot or feasibility randomised trial in the title	1
	1b	Structured summary of pilot trial design, methods, results, and conclusions (for specific guidance see CONSORT abstract extension for pilot trials)	2-3
<b>Introduction</b>			
Background and objectives	2a	Scientific background and explanation of rationale for future definitive trial, and reasons for randomised pilot trial	5-6
	2b	Specific objectives or research questions for pilot trial	5-6
<b>Methods</b>			
Trial design	3a	Description of pilot trial design (such as parallel, factorial) including allocation ratio	7-8
	3b	Important changes to methods after pilot trial commencement (such as eligibility criteria), with reasons	NA
Participants	4a	Eligibility criteria for participants	8
	4b	Settings and locations where the data were collected	10-11
	4c	How participants were identified and consented	7
Interventions	5	The interventions for each group with sufficient details to allow replication, including how and when they were actually administered	8-10 & 24
Outcomes	6a	Completely defined prespecified assessments or measurements to address each pilot trial objective specified in 2b, including how and when they were assessed	10-12
	6b	Any changes to pilot trial assessments or measurements after the pilot trial commenced, with reasons	NA
	6c	If applicable, prespecified criteria used to judge whether, or how, to proceed with future definitive trial	NA
Sample size	7a	Rationale for numbers in the pilot trial	11
	7b	When applicable, explanation of any interim analyses and stopping guidelines	NA
Randomisation:			
Sequence generation	8a	Method used to generate the random allocation sequence	NA
	8b	Type of randomisation(s); details of any restriction (such as blocking and block size)	NA

Allocation concealment mechanism	9	Mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned	NA
Implementation	10	Who generated the random allocation sequence, who enrolled participants, and who assigned participants to interventions	NA
Blinding	11a	If done, who was blinded after assignment to interventions (for example, participants, care providers, those assessing outcomes) and how	NA
	11b	If relevant, description of the similarity of interventions	NA
Statistical methods	12	Methods used to address each pilot trial objective whether qualitative or quantitative	11-12
<b>Results</b>			
Participant flow (a diagram is strongly recommended)	13a	For each group, the numbers of participants who were approached and/or assessed for eligibility, randomly assigned, received intended treatment, and were assessed for each objective	25
	13b	For each group, losses and exclusions after randomisation, together with reasons	25
Recruitment	14a	Dates defining the periods of recruitment and follow-up	13 & 25
	14b	Why the pilot trial ended or was stopped	13
Baseline data	15	A table showing baseline demographic and clinical characteristics for each group	26-27
Numbers analysed	16	For each objective, number of participants (denominator) included in each analysis. If relevant, these numbers should be by randomised group	28-29
Outcomes and estimation	17	For each objective, results including expressions of uncertainty (such as 95% confidence interval) for any estimates. If relevant, these results should be by randomised group	NA
Ancillary analyses	18	Results of any other analyses performed that could be used to inform the future definitive trial	13-15
Harms	19	All important harms or unintended effects in each group (for specific guidance see CONSORT for harms)	25
	19a	If relevant, other important unintended consequences	NA
<b>Discussion</b>			
Limitations	20	Pilot trial limitations, addressing sources of potential bias and remaining uncertainty about feasibility	17-18
Generalisability	21	Generalisability (applicability) of pilot trial methods and findings to future definitive trial and other studies	16-17
Interpretation	22	Interpretation consistent with pilot trial objectives and findings, balancing potential benefits and harms, and	15-16

		considering other relevant evidence	
	22a	Implications for progression from pilot to future definitive trial, including any proposed amendments	15-18
<b>Other information</b>			
Registration	23	Registration number for pilot trial and name of trial registry	NA
Protocol	24	Where the pilot trial protocol can be accessed, if available	NA
Funding	25	Sources of funding and other support (such as supply of drugs), role of funders	19
	26	Ethical approval or approval by research review committee, confirmed with reference number	7

632

633 Citation: Eldridge SM, Chan CL, Campbell MJ, Bond CM, Hopewell S, Thabane L, et al. CONSORT 2010  
634 statement: extension to randomised pilot and feasibility trials. BMJ. 2016;355. This is an Open Access article  
635 distributed in accordance with the terms of the Creative Commons Attribution (CC BY 3.0) license  
636 (<http://creativecommons.org/licenses/by/3.0/>), which permits others to distribute, remix, adapt and build upon this  
637 work, for commercial use, provided the original work is properly cited.

638 \*We strongly recommend reading this statement in conjunction with the CONSORT 2010, extension to  
639 randomised pilot and feasibility trials, Explanation and Elaboration for important clarifications on all the items. If  
640 relevant, we also recommend reading CONSORT extensions for cluster randomised trials, non-inferiority and  
641 equivalence trials, non-pharmacological treatments, herbal interventions, and pragmatic trials. Additional  
642 extensions are forthcoming: for those and for up-to-date references relevant to this checklist, see [www.consort-](http://www.consort-statement.org)  
643 [statement.org](http://www.consort-statement.org).

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645

**Supplementary Table S2: Satisfaction by prosthesis type (25 participants)**

	All patients N = 25	Knee prosthesis N = 9	Hip prosthesis N = 16
<b>Satisfaction at the end of the MPP*</b>			
Entire program quality			
Very poor	0 (0)	0 (0)	0 (0)
Poor	0 (0)	0 (0)	0 (0)
Suitable	8 (32)	1 (11)	7 (44)
Good	2 (8)	1 (11)	1 (6)
Excellent	15 (60)	7 (78)	8 (50)
Home sessions			
Moderately satisfied	0 (0)	0 (0)	0 (0)
Quite satisfied	4 (16)	2 (22)	2 (12)
Very satisfied	21 (84)	7 (78)	14 (88)
ODH functional sessions			
Moderately satisfied	0 (0)	0 (0)	0 (0)
Quite satisfied	6 (24)	3 (33)	3 (19)
Very satisfied	19 (76)	6 (67)	13 (81)
ODH exergame sessions <sup>†</sup>			
Moderately satisfied	7 (28)	3 (33)	4 (25)
Quite satisfied	6 (24)	1 (11)	5 (31)
Very satisfied	12 (48)	5 (56)	7 (44)
ODH dietary sessions			
Moderately satisfied	6 (24)	2 (22)	4 (25)
Quite satisfied	8 (32)	1 (11)	7 (44)
Very satisfied	11 (44)	6 (67)	5 (31)
ODH psychological sessions			
Moderately satisfied	4 (16)	2 (22)	2 (13)
Quite satisfied	1 (4)	0 (0)	1 (6)
Very satisfied	20 (80)	7 (78)	13 (81)
ODH empowerment sessions <sup>‡</sup>			
Moderately satisfied	1 (4)	0 (0)	1 (6)
Quite satisfied	2 (8)	1 (11)	1 (6)
Very satisfied	22 (88)	8 (89)	14 (88)
Entire program duration			
Too short	4 (16)	1 (11)	3 (19)
Too long	0 (0)	0 (0)	0 (0)
Well adapted	21 (84)	8 (89)	13 (81)
ODH session duration			
Too short	1 (4)	1 (11)	0 (0)
Too long	1 (4)	0 (0)	1 (6)
Well adapted	23 (92)	8 (89)	15 (94)
Number of ODH sessions/week			
Insufficient	0 (0)	0 (0)	0 (0)
Too high	0 (0)	0 (0)	0 (0)
Perfect	25 (100)	9 (100)	16 (100)
<b>Satisfaction at 30 days<sup>§</sup></b>			
“In your opinion, the protocol has ...			
Better prepared you for surgery			
Little agree	5 (20)	1 (11)	4 (25)
Quite agree	7 (28)	3 (33)	4 (25)
Totally agree	13 (52)	5 (56)	8 (50)

Helped you manage your pain better			
Little agree	7 (28)	0 (0)	7 (44)
Quite agree	11 (44)	5 (56)	6 (38)
Totally agree	7 (28)	4 (44)	3 (18)
Helped you better recover from walking			
Little agree	7 (28)	3 (33)	4 (25)
Quite agree	7 (28)	2 (22)	5 (31)
Totally agree	10 (40)	4 (44)	6 (38)
<i>Missing value</i>	<i>1 (4.0)</i>	<i>0 (0)</i>	<i>1 (6.0)</i>
Recovered your ability to perform everyday tasks			
Little agree	4 (16)	1 (11)	3 (19)
Quite agree	12 (48)	4 (44)	8 (50)
Totally agree	8 (32)	4 (44)	4 (25)
<i>Missing value</i>	<i>1 (4.0)</i>	<i>0 (0)</i>	<i>1 (6.0)</i>
Helped you feel less anxious before your operation			
Little agree	7 (28)	2 (22)	5 (31)
Quite agree	9 (36)	2 (22)	7 (44)
Totally agree	8 (32)	5 (56)	3 (19)
<i>Missing value</i>	<i>1 (4.0)</i>	<i>0 (0)</i>	<i>1 (6.0)</i>
“Would you recommend this protocol to someone you know?”			
Yes	25 (100)	9 (100)	16 (100)
No	0 (0)	0 (0)	0 (0)

647 Data are n (%).

648 MPP, multimodal prehabilitation program; ODH, one-day hospital

649 \*qualitative structured questionnaires by phone after ODH session 6 and before surgery

650 †exergame sessions: 40-min session with a video game based on motion capture

651 ‡empowerment sessions: two 10-min videos during one ODH session explaining post-operative complications and key concepts of surgery

653 §phone-based structured interviews with patients, 30 days after surgery

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