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Impact of an educational intervention on ankle-brachial index performance among medical students and fidelity assessment at month-6

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HAL Authorization

1 **Impact of an educational intervention on ankle-brachial index performance among**
2 **medical students and fidelity assessment at month-6**

3

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26

27 **ABSTRACT**

28 **Background:** The resting ankle-brachial index (ABI) is a clinical test to diagnose peripheral
29 artery disease (PAD). The Wyatt's score has been proposed to assess the students'
30 performance on ABI measurement on a healthy volunteer (HV). No study has shown that this
31 score is sensitive to different teaching methods. In this randomized-controlled-trial, we
32 wanted to determine whether didactic learning alone or didactic learning combined with
33 experiential learning improve proficiency in the ABI procedure assessed by the Wyatt's score.

34 **Methods:** Medical students (n = 30) received a didactic learning, including i) a presentation
35 of the ABI guidelines and ii) a video demonstration. Each student, was then randomized into
36 two groups ("the no experiential learning group" and "the experiential learning group"). An
37 initial evaluation was performed after the didactic learning and then the final evaluation at the
38 end of the intervention. A student was considered to be proficient when he performed a
39 correct ABI procedure on a HV. The correct procedure corresponds to: i) correctly answered
40 Wyatt's score and ii) a difference of an ABI measurement between a professor in vascular
41 medicine and a student ≤ 0.15 .

42 **Results:** No student was proficient at the initial evaluation. At the final evaluation, there was
43 a significant difference between the number of proficient students for the Wyatt's score
44 depending on their learning group (didactic alone (1/10) or didactic + experiential training
45 (15/20)) and also for the ABI procedure (didactic alone (0/10) or didactic + experiential
46 training (16/20)). At month-6, among the twelve students who passed the final evaluation,
47 four passed both the Wyatt's score and the ABI measurement.

48 **Conclusions:** Our study demonstrates that the Wyatt's score was sensitive to an educational
49 intervention and no improvement was found in the case of no experiential learning. The
50 Wyatt's score could be used to evaluate student on ABI measurement after an educational
51 intervention.

52 **Trial Registration:** A randomized controlled trial (RCT) was conducted in the vascular
53 medicine department of Rennes University Hospital (France). This was approved by the
54 ethics review board of our institution (n° 16.150).

55

56 **Keywords:** peripheral artery disease, teaching, diagnosis, vascular medicine, medical
57 students

58

59 **Word Count:** Abstract: 335; Main Body: 2582

60

61 **List of abbreviations:** PAD: Peripheral Arterial Disease; ABI: Ankle-Brachial Index; TASC:
62 Trans-Atlantic Inter-Society Consensus; AHA: American Heart Association; CVD:
63 Cardiovascular Diseases; RCT: randomized controlled trial; HV: Healthy Volunteer

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77 BACKGROUND

78 Peripheral Arterial Disease (PAD) is a highly debilitating disease that affects 202 million
79 people around the world and about 7 million people in France⁽¹⁾. Noninvasive physiologic
80 vascular studies such as the ankle-brachial index (ABI; ratio of the highest systolic blood
81 pressure measured at the ankle to that measured at the brachial artery) at rest play an
82 important role in the diagnosis and characterization in PAD of the lower extremity⁽²⁾. ABI is a
83 quick and cost-effective examination in primary care and should be used to screen patients
84 meeting the Trans-Atlantic Inter-Society Consensus Document on Management of PAD
85 (TASC) II criteria⁽³⁾.

86 Recent guidelines from the American Heart Association (AHA) have proposed methods for
87 measurement and interpretation of the ABI, as well as the ABI learning procedure⁽⁴⁾. ABI is
88 measured and calculated as the ratio of the highest systolic blood pressure in each ankle from
89 the right and left posterior tibial or dorsalis pedis arteries, divided by the highest brachial
90 systolic blood pressure. A resting ABI value of 0.90 or less defines PAD diagnosis. Also, ABI
91 is a measure of atherosclerosis severity in the legs and is associated with both atherosclerotic
92 risk factors and prevalent cardiovascular diseases (CVD) in other vascular beds⁽⁴⁾. ABI may
93 be used as a risk marker both in the general population with established or free of clinical CV
94 diseases⁽⁴⁾. Given the importance of ABI in screening for PAD but also for CVD especially in
95 asymptomatic patients, it is important for vascular physician to know ABI measurement and
96 its interpretation, but above all it requires technical learning to obtain expertise from the
97 beginning of medical studies and to optimize patient care. Previous study of our group has
98 shown in a first randomized trial that didactic learning alone is insufficient to gain proficiency
99 in the ABI procedure and combining didactic learning with experiential learning significantly
100 improved the students' proficiency⁽⁵⁾. Moreover, Wyatt *et al.* have defined a scoring sheet
101 (Wyatt's score) to assess the proficiency in performance of the ABI⁽⁶⁾ (Figure 1). They have

102 shown that baseline knowledge of the ABI test was poor among a sample of internal medicine
103 residents and requires action to improve ABI learning in medical school and residency
104 programs⁽⁶⁾. The aims of this study are to determine i) whether didactic learning alone or
105 didactic learning combined with experiential learning improve proficiency in the ABI
106 procedure assessed by the Wyatt's score, ii) to assess the fidelity of ABI measurement at
107 month-6.

108

109 **METHODS**

110 **Study design**

111 A randomized controlled trial (RCT) was conducted in the vascular medicine department of
112 Rennes University Hospital (France). This was approved by the ethics review board of our
113 institution (n° 16.150). All included medical students signed an informed consent form and
114 healthy volunteer (HV) and patient cohorts were orally informed according to the approved
115 study procedure.

116

117 **Didactic Learning**

118 For this study, 4th to 6th year undergraduate medical students (eighteen women and twelve
119 men), with no prior experience in the evaluation of ABI received a specific one-hour didactic
120 course provided by an experienced vascular specialist including i) a presentation of the AHA
121 guidelines (50 min)⁽⁴⁾ and ii) a video demonstration of the ABI procedure with a clear
122 description of each step and emphasis on correct technique (10 min). In this video, a vascular
123 specialist performs an ABI measurement on both lower extremities of a patient. The video
124 was recorded to i) explain the utility of the measurement in clinical practice, ii) describe the
125 appropriate care of the Doppler ABI, iii) demonstrate the location of the pulses on the arms

126 and lower legs, iv) listen to the quality of the pulse of arterial blood flow, v) list the tips for
127 effectively using the Doppler probe, vi) calculate the ABI, and vii) state the significance of
128 the ABI result.

129

130 **Baseline assessment**

131 Following this didactic course, the students were invited to complete the Wyatt's score and
132 perform an ABI measurement. A technician supervised an initial ABI procedure evaluation.
133 During this evaluation, each medical student attempted to i) perform an ABI measurement for
134 the right or left lower limb extremity of a HV, and ii) select the appropriate numerator and
135 denominator required to calculate the ABI of a hypothetical patient. One minute after the
136 student finished, a vascular specialist blinded to the students' ABI measures came into the
137 examination room and repeated the ABI measurement.

138

139 **Randomization**

140 Then, they were randomized into two groups as illustrated in Figure 2 ("no experiential
141 learning group", "experiential learning group"). This latter group was randomly divided into
142 two groups: "experiential learning on HV group" and "experiential learning on patients
143 group".

144

145 **Educational Intervention**

146 The HV cohort had no medical risk factor and normal ABIs, whereas the patient cohort
147 consisted of consecutive patients referred for PAD diagnosis. We excluded patients with
148 recent below the knee lower extremity arterial bypass, the presence of open wounds, ulcers, or
149 fistulae contraindicating cuff placement, or who were unable to provide oral informed
150 consent.

151 For experiential learning on HV, students came three times in pairs for a one-hour session
152 during which students trained on one another. For experiential learning on patients, students
153 came three times individually when a vascular ultrasound exam was programmed. For each
154 experiential learning session, students performed an ABI measurement on both lower
155 extremities (right and left lower extremities) of the volunteer under the vascular specialist's
156 supervision (i.e., seven pressures recorded: right brachial artery, right posterior tibial artery,
157 right dorsalis pedis artery, left posterior tibial artery, left dorsalis pedis artery, left brachial
158 artery and right brachial artery). The equipment provided to the student included adult
159 medium and large sized blood pressure cuffs, an 8 MHz Doppler ultrasound probe, ultrasound
160 gel, a stethoscope, and an automatic blood pressure monitor, as previously reported by *Wyatt*
161 *et al*⁽⁶⁾. Students were then instructed to calculate and interpret the ABI, according to the
162 AHA recommendations (i.e., the ABI of each leg should be calculated by dividing the higher
163 of the posterior tibial artery or dorsalis pedis artery pressure by the higher of the right or left
164 arm systolic blood pressure).

165 During each experiential learning session, the vascular specialist identified all problems of the
166 measuring process that may affect the accuracy of the ABI to provide pertinent and
167 personalized feedback to the students. For example, the vascular specialist was careful with
168 the choice or attachment of the cuff, the position and angle of the Doppler probe, or of
169 insufficient contact via the transmission gel for the Doppler probe, which may dislocate
170 during the measurement and deflation of the cuff.

171 Immediately after completion of the ABI measurement, the vascular specialist provided i)
172 feedback to the students on their individual errors in performing the ABI measurement and its
173 calculation and interpretation and ii) a demonstration of the ABI measurement on both lower
174 extremities of the same volunteer.

175

176 Final assessment

177 The final assessment was performed following the same procedure as the baseline assessment.

178

179 Outcome measures

180 A student was considered to be proficient in performing the ABI measurement if he correctly
181 answered the 15-items of the Wyatt's score and performed the following procedure during the
182 evaluation on a HV: i) installed the volunteer in a supine position with the head and heels
183 supported, ii) used the appropriate device among the equipment provided for each participant
184 (i.e., sphygmomanometer cuff with a width of a least 40% of the limb circumference placed
185 just above the malleoli, 8 MHz Doppler probe with Doppler gel applied over the probe and
186 placed in the area of the pulse at a 45° to 60° angle to the surface of the skin), iii) inflated the
187 cuff progressively up to 20 mmHg above the level of flow signal disappearance and then
188 deflated slowly to detect the pressure level of flow signal reappearance, iv) performed the
189 pressure measurements in the accurate order (i.e. for the right ABI measurement: right
190 brachial artery, right posterior tibial artery, right dorsalis pedis artery, left brachial artery, and
191 right brachial artery again), v) recorded each pressure, vi) selected the appropriate numerator
192 and denominator to calculate the ABI, and vii) obtained an accurate ABI. Even if the ABI of
193 the student was accurate, but the pressure measurements were not performed in the correct
194 order, or the sphygmomanometer cuff was not correctly placed, the student was not
195 considered to be proficient.

196 An ABI was considered to be accurate if the difference between the ABIs measured by the
197 vascular specialist and the student was ≤ 0.15 , as previously reported^(7,8). Furthermore, this
198 cut-off was chosen since a decrease of the ABI > 0.15 over time is effective for detecting
199 significant PAD progression, as stated in the AHA recommendations⁽⁴⁾. The intra-observer

200 coefficient of variation for the ABI in our vascular laboratory is 8% (Typical error of the
201 estimate is 0.06).

202

203 **Fidelity assessment at month-6**

204 Between the beginning of the study and the evaluation at day-28, only the students of the
205 group "experiential learning group" received the 3 sessions of practical training. Between the
206 end of the evaluation and the follow-up at month-6, no student received practical training.

207 Students considered proficient having passed all the theoretical and practical tests at the final
208 assessment were invited to perform another evaluation at month-6 in order to verify the
209 acquisition of knowledge and skills of measuring the ABI.

210

211 **Statistical analysis**

212 Statistical analysis was performed using the computing environment R (R Development Core
213 Team, 2005). A Fischer test was used to compare the number of students proficient in
214 performing the Wyatt's score and ABI procedure in each group between the initial and final
215 evaluations. At month-6, the percentage of success was calculated for the Wyatt's score and
216 the ABI procedure according to the randomization group of each student.

217 Between-group comparisons were also performed at the initial and final evaluations. A two-
218 tailed p value < 0.05 was considered to be statistically significant.

219

220 **RESULTS**

221 Thirty medical students were included in this RCT (Figure 2) where they are completed the
222 baseline Wyatt's score and performed ABI assessment. Of the initial cohort of 30 students, 20
223 (67%) were randomized in two groups of 10 and received the educational intervention. One

224 group performed the three times repeat assessment on HV while another one performed it on
225 patients.

226 At the initial evaluation, after the didactic learning alone, no student was proficient in
227 performing the ABI procedure while 2 (6.7%) passed the Wyatt's score.

228 At the final evaluation, the number of proficient students for the Wyatt's score in the no
229 training group was not significantly improved compared with the initial evaluation (1/10 vs
230 1/10; $p=ns$; Figure 3, panel A). The same results were observed for the ABI procedure in this
231 group (1/10 vs 2/10; $p=ns$; Figure 3, panel B). In the experiential learning group (training on
232 HV), the number of proficient students for the Wyatt's score significantly increased (0/10 vs
233 9/10; $p < 0.001$; Figure 3, panel A) and also for the ABI procedure (0/10 vs 8/10; $p < 0.001$;
234 Figure 3, panel B) after three experiential ABI measurements on both lower extremities (right
235 and left). In the experiential learning group (training on patient), the number of proficient
236 students for the Wyatt's score was not significantly improved (1/10 vs 6/10; $p=0.07$; Figure 3,
237 panel A) while for the ABI procedure, it was significantly improved (0/10 vs 8/10; $p < 0.001$;
238 Figure 3, panel B) after three experiential ABI measurements on both lower extremities (right
239 and left).

240 At the final evaluation, there was a significant difference between the number of proficient
241 students for the Wyatt's score depending on their learning group (didactic alone (1/10) or
242 didactic + experiential training (15/20)) and also for the ABI procedure (didactic alone (0/10)
243 or didactic + experiential training (16/20)). There was no significant difference in the
244 proficiency of the students according to their experiential learning group affiliation (HV vs
245 patients).

246

247 **Fidelity at month-6**

248 At the final evaluation, only 1 student in the no training group was successful, while in the
249 experiential learning group, 6 students from the training on HV group and 5 from the training
250 on patient group were successful. At month-6, the student of the no training group failed. In
251 the group receiving the interventional education, 3/5 (60%) passed the Wyatt's score and 1/5
252 (20%) the ABI procedure in the training on patient group. 5/6 (83%) passed the Wyatt's score
253 and 3/5 (60%) the ABI procedure in the training on HV group. (Figure 4)

254

255 **DISCUSSION**

256 ABI is an important and widely non-invasive used tool for the diagnosis of PAD and is part of
257 the medical curriculum. In this we showed that i) didactic learning alone (no training), even
258 with a video demonstration, is insufficient to ensure proficiency of medical students in
259 performing the Wyatt's score and the ABI procedure; ii) didactic learning associated with an
260 intervention that combined three experiential training sessions with direct feedback to
261 participants significantly improved the students' proficiency relative to didactic learning alone
262 for both Wyatt's score and ABI procedure; iii) at month-6, there is no fidelity for the only one
263 student who passed the final evaluation while in the experiential group, the fidelity decreased
264 more for the ABI procedure than the Wyatt's score leading the need for continuous training.

265 Our study demonstrates that the Wyatt's score was sensitive to an educational intervention
266 and no improvement was found in case of no experiential learning. Therefore, the Wyatt's
267 score could be used for the assessment of vascular medicine students. It should be of interest
268 to validate it among PAD patients.

269 Teaching of the ABI procedure in major medical schools consists of only a didactic session,
270 evaluated by questionnaire⁽⁹⁻¹¹⁾, that is insufficient to ensure competence with the theoretical
271 procedure. Our study supports dropping didactic learning alone or combining it with

272 experiential training. Training should include practical instruction on how to perform an ABI
273 but also a didactical teaching following the international recommendation⁽⁴⁾.

274 There was no difference in student proficiency between the two experiential learning
275 modalities (HV vs patients). Thus, experiential learning on HV may be preferable from a
276 practical point of view (*i.e.* organization, feasibility) as a first step of teaching the ABI
277 procedure.

278 The strength of this study is that we used the ABI measurement value of our vascular
279 specialists as a “gold standard” for comparison with the measurements performed by the
280 students.

281

282 **Limitations**

283 This study had some limitations. First, students in the no training group received only one
284 hour of didactic learning. It cannot be excluded that repeat didactic learning might have
285 improved the final proficiency of the students in completing the Wyatt’s score and measuring
286 the ABI. However, following only one didactic course corresponds to a current practice in
287 most French medical schools⁽¹²⁾. The present study confirms that such learning is insufficient
288 and experiential training should be performed, as suggested by other studies^(13,14).

289

290 **CONCLUSION**

291 Didactic learning alone is insufficient for proficiency in performing the Wyatt’s score and
292 ABI procedure on HV; it should be combined with experiential learning.

293 The Wyatt’s score could be used to evaluate student on ABI measurement after an educational
294 intervention. In case of success of the Wyatt’s score, an ABI done by an expert is not
295 required. Nevertheless, without continuous practice, we note that at month-6, the theoretical
296 knowledge on the Wyatt’s score as well as the skills for the measurement of the ABI do not

297 persist Further studies are needed to i) determine the minimal amount of experiential learning
298 required to be proficient; ii) assess the effect of experiential learning modalities (HV vs
299 patient) on a larger population; and iii) evaluate the students' proficiency in a follow-up
300 study.

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305

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314 **Availability of data and materials**

315 The datasets used and/or analysed during the current study available from the corresponding
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317

318 **Permission Information**

319 The authors do hereby declare that all illustrations and Figures in the manuscript are entirely
320 original and do not require reprint permission.

321

322 **Contributors**

323 Dr Loukman OMARJEE contributed to literature search, data collection, data analysis, data
324 interpretation, writing the report and final approval of the version to be published.

325 Dr Céline DONNOU contributed to literature search, data analysis, data interpretation,
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327 Ms Ségolène CHAUDRU contributed to study management, literature search, data analysis,
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337 Dr Vincent JAQUINANDI contributed to literature search, data collection, data analysis, data
338 interpretation, revising the intellectual content and final approval of the version to be
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340 Dr Olivier STIVALET contributed to literature search, data collection, data analysis, data
341 interpretation, revising the intellectual content and final approval of the version to be
342 published.

343 Pr Guillaume MAHE contributed to study design, literature search, data collection, data
344 analysis, data interpretation, revising the intellectual content and final approval of the version
345 to be published.

346

347 Ethics approval and consent to participate

348 Ethical approval of the study was obtained from the Ethic Committee of the Rennes
349 University Hospital (France) and approved by the institutional review board (IRB) (n°
350 16.150). All included medical students signed an informed consent form and HV and patient
351 cohorts were orally informed according to the approved study procedure.

352 All procedures contributing to this work comply with the ethical standards of the relevant
353 national and institutional committees on human experimentation and with the Helsinki
354 Declaration of 1975, as revised in 2008. The objectives of the study were explained to the
355 participants who were informed that their participation was voluntary, and anonymity was
356 assured.

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435 **Figure titles:**

436 **Figure 1:** Wyatt's Score

437 **Figure 2:** Study design flow chart

438 **Figure 3, panel A:** Wyatt's score evaluation

439 **Figure 3, panel B:** ABI measurement on healthy volunteers

440 **Figure 4:** Fidelity assessment at month-6

441

442 **Figure legends:**

443 **Figure 1:** Wyatt's Score for Ankle-brachial index measurement

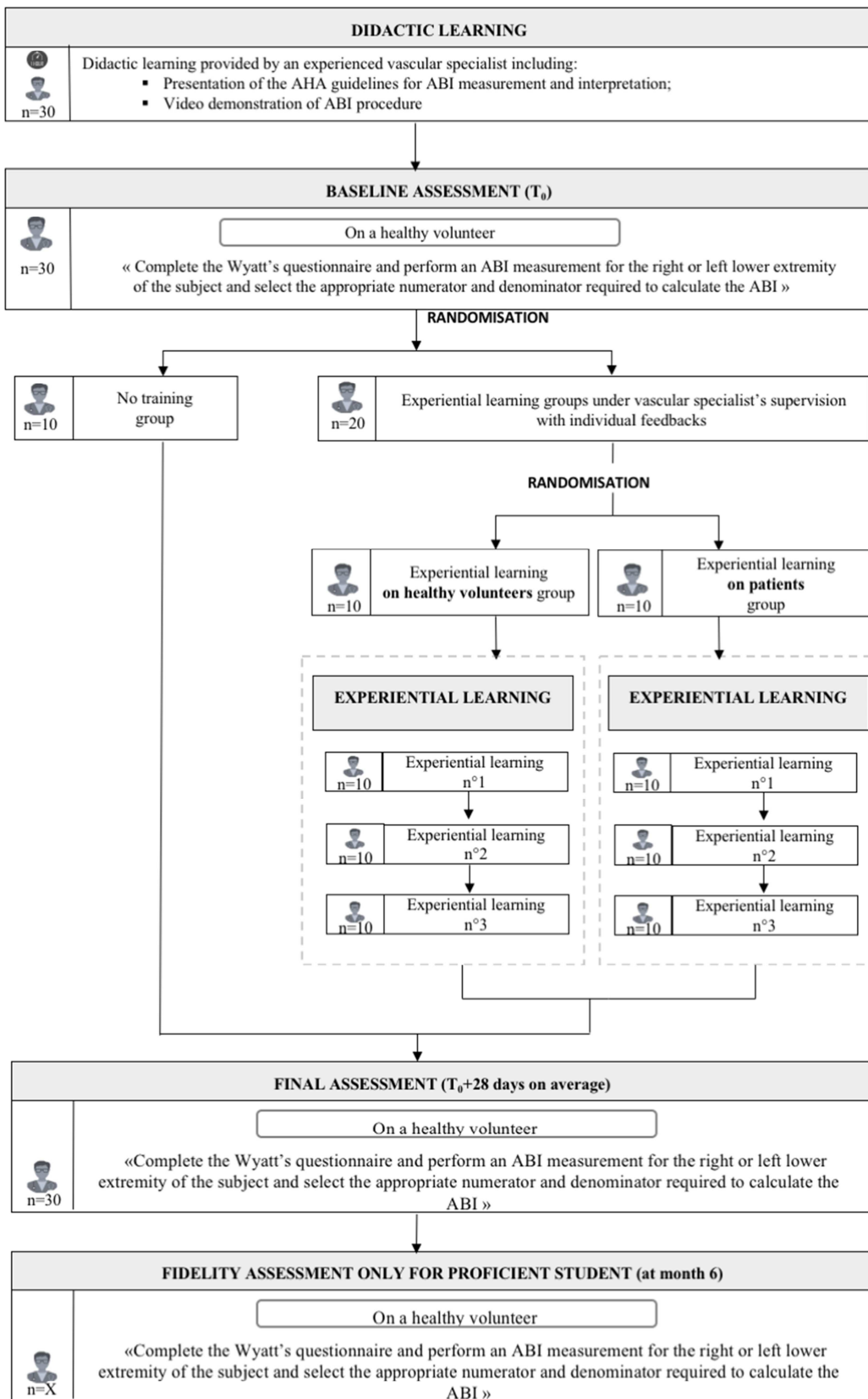
444 **Figure 2:** Study design flow chart. ABI: Ankle-brachial index X: number of students
445 proficient at the final assessment (T0+28 days on average)

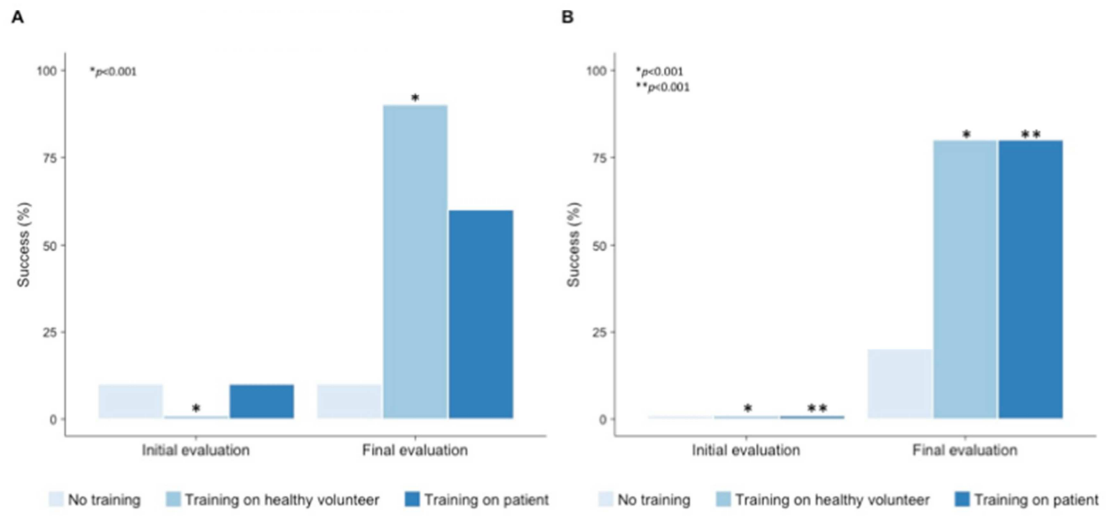
446 **Figure 3:** Comparison of the number of medical students proficient in performing the Wyatt's
447 score (Panel A) and resting ABI (Panel B) procedure on healthy volunteers at the initial and
448 final evaluation between the the 'no training group', the 'experiential learning group training
449 on healthy volunteer' and the 'experiential learning group training on patients'

450

451 **Figure 4:** Percentage of success of medical students proficient at the final evaluation in
452 performing the Wyatt's score and resting ABI procedure on healthy volunteers at month-6
453 between the 'no training group', the 'experiential learning group training on healthy
454 volunteer' and the 'experiential learning group training on patients'.

Wyatt's Score		Score
Element of ABI measurement		
Arm		
A. Use of arm cuff		1
B. Use of Doppler probe to acquire systolic pressure from brachial vessels		1
(i) Right brachial artery		
(a) Doppler signal obtained from right brachial artery		1
(b) Systolic pressure recorded within 5 mmHg of onset of Doppler signal		1
(ii) Left brachial artery		
(a) Doppler signal obtained from left brachial artery		1
(b) Systolic pressure recorded within 5 mmHg of onset of Doppler signal		1
C. Systolic pressure acquired from both brachial arteries		1
Right leg		
A. Use of leg cuff		1
B. Correct placement of cuff over lower leg		1
C. Use of Doppler probe to acquire systolic pressure from tibial vessels		1
(i) Dorsalis pedis artery		
(a) Doppler signal obtained from right dorsalis pedis artery		1
(b) Systolic pressure recorded within 5 mmHg of onset of Doppler signal		1
(ii) Posterior tibial artery		
(a) Doppler signal obtained from right posterior tibial artery		1
(b) Systolic pressure recorded within 5 mmHg of onset of Doppler signal		1
D. Systolic pressure acquired from both pedal arteries		1
Total score		15





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