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► **To cite this version:**

Yosra Cherni, David Desseauve, Arnaud Decatoire, Nikolaus Veit-Rubinc, Mickael Begon, et al.. Evaluation of ligament laxity during pregnancy. *Journal of Gynecology Obstetrics and Human Reproduction*, 2019, 48 (5), pp.351-357. 10.1016/j.jogoh.2019.02.009 . hal-02446739

**HAL Id: hal-02446739**

**<https://hal.science/hal-02446739>**

Submitted on 22 Oct 2021

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## EVALUATION OF LIGAMENT LAXITY DURING PREGNANCY

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# EVALUATION OF LIGAMENT LAXITY DURING PREGNANCY

## 1 ABSTRACT

2 Objective: Pregnancy-related changes in ligament laxity have been shown to be associated with various  
3 disorders such as back pain or pelvic floor disorders. The purpose of this study was to assess laxity  
4 changes during pregnancy by confronting different methods in order to suggest a simple clinical tool  
5 helping to prevent the aforementioned problems.

6 Design: 17 pregnant women were evaluated at the first, second and third trimesters as cases and 16 non-  
7 pregnant women participated as controls. Ligamentous laxity was measured using an extensometer for the  
8 metacarpophalangeal joint of the index, a fingertip to floor test and a sit and reach test to assess hip and  
9 lumbar flexibility and the Beighton score. Statistical analysis included independent samples *t*-tests,  
10 analysis of variance and Pearson correlation coefficients.

11 Results: Laxity of the metacarpophalangeal joint increased by 11% from the first to the second trimester  
12 of pregnancy and stabilized until delivery. The Beighton score was significantly higher in the second  
13 trimester of pregnancy ( $p < 0.05$ ). The flexibility of the hip and lumbar vertebra showed a significant  
14 increase of the distance measured between the foot soles and the middle fingers at third trimester  
15 ( $p < 0.05$ ). A moderate correlation was observed between the results given by the extensometer and the  
16 Beighton score in both the cases and the control group at first trimester ( $r = 0.60, p < 0.05$ ) but none was  
17 found for the two hip and lumbar flexibility tests.

18 Conclusion: Laxity reached its maximum at the second trimester. The combination of an objective  
19 measurement by the extensometer and a global evaluation of the laxity by the Beighton' score for  
20 example may be useful for a daily assessment of laxity. However, the chosen clinical tests don't seem  
21 appropriate to be used alone in pregnant women

22 **Key words:** Hypermobility, Quantification, Extensometer, Clinical tests

23

## 1. INTRODUCTION

Pregnancy is a unique physiological condition that induces large morphologic changes (*e.g.* weight and posture) and also modifications of intrinsic parameters like ligamentous laxity [1]. The ligamentous laxity is at its maximum in early childhood after this, it decreases rapidly until adulthood [2]. However, in the female population, this gradual decline may be suspended and even reversed during pregnancy. In this regard, some authors explain that some hormones such as relaxine, progesterone or oestradiol which levels increase during pregnancy modify the ligament structure [3–5]. These hormonal changes result in physiological relaxation of the ligaments in the pelvic joints in order to enhance the passage of the baby through the birth canal [6]. This loosening would enable the pelvic joint to become more flexible but, as a counterpart, would also affect the pelvic joint and the spine responses to mechanical load. Some authors hypothesize indeed that these modifications of pelvic joint and spine responses favor pelvic dysfunctions and the occurrence of pain in this body region [7,8]. ~~Thus, Ostgaard and colleagues outlined the increase in ligamentous laxity as a potential risk factor for instability of the sacroiliac joints whereas a study by Lindgren and colleagues noted that the peripheral laxity is higher in women with low back pain during pregnancy [7]. Many questions remain however open regarding the exact hormonal factors and the mechanisms leading to ligamentous property modifications and pelvic dysfunctions since relaxine alone doesn't seem to be directly related to pelvic girdle pain.~~ During pregnancy, hormonal changes affect not only ligaments in the pelvic joints but more generally collagen of connective tissues [9] and therefore ligaments and tendons in general (*e.g.*, hand [10], wrist [11]). The observations concerning pelvic and spine joints are then extendable to the human body joints in general such as increased laxity may be related to various musculoskeletal disorders and increased pain in various joints of the body during pregnancy [12,13]. ~~Hyperlaxity has also been shown to be linked with the development of pelvic floor disorders pre and post partum [13].~~ In the aforementioned studies investigating the relation between ligament laxity and disorders during pregnancy, the evolution of ligament laxity hasn't been assessed throughout pregnancy. Nevertheless, early detection of its increase would be of particular interest in order to develop prevention of various disorders appearing with pregnancy.

In the literature, there is then a wide variety of *in vivo* laxity assessment devices and methods. The first type of methods try to assess directly the lengthening of a ligament after applying a specific force using medical imaging [14] or knee ligament arthrometers [15,16]. This methods allow measurement of small

53 laxity changes with an accuracy up to 0.1 mm [17] but is quite expensive for a clinical follow up and  
54 requires some technical expertise. Moreover, not many ligaments can be isolated.

55 The second category of devices proposes to evaluate indirectly the ligament laxity through the  
56 measurement of articular mobility [1,7,8,11] even though articular mobility results from the mechanical  
57 behavior of various ligaments, tendons and capsules [18]. Typically, these systems, such as the  
58 extensometer of Jobbins [19], measure the amplitude reached by a joint of the pregnant woman for a  
59 specific torque applied on this joint. Such devices are portable, easy to use, affordable, atraumatic and  
60 reliable [1]. The main drawback is that the proposed devices measure flexibility in upper limb joint. Now,  
61 upper joints are affected by pregnancy-related changes in laxity but less involved in pathology.

62 The third category of methods would be clinical tests that estimate joint flexibility. The Beighton score  
63 [20] is the most commonly used test to assess the overall ligamentous laxity. It is a nine-point score  
64 evaluating laxity in the upper and lower limbs and lumbar and hip flexibility with a score  $\geq 4/9$  required to  
65 conclude a generalized hyper joint mobility. The reliability and reproducibility of this score was  
66 suggested as good to excellent in screening for generalized joint laxity in females [21] and children [22]  
67 and has already been used in pregnant women [1,23]. Calguneri and colleagues observed no significant  
68 difference in Beighton scores between the third trimester and postpartum [1]. Van Dongen and colleagues  
69 used the Beighton scale to study the generalized laxity in pregnant South African women [23]. They  
70 showed that hypermobility in this women is low (only 4.9% of the 509 pregnant women), decreasing with  
71 age, but not increasing during pregnancy. However, the main limit of the Beighton score would be the  
72 computation of the score based on the sum of one and zeros corresponding to the ability to reach or not  
73 specific joint postures.

74 In the literature, other more targeted clinical tests have been suggested to evaluate the lower back  
75 flexibility such as the “fingertip to floor test” [24] or the “sit and reach test” [25]. These tests have been  
76 intensively used in epidemiologic studies [26] and sport sciences [27]. They are easy to administer and  
77 require minimal skills training [26]. To the best of our knowledge, they have never been used to assess  
78 joint laxity in pregnant women. Conversely to the Beighton score, the performance corresponds to a  
79 distance, which is continuous measure. As such, they could be more sensitive to small changes in joint  
80 laxity and then present a good alternative to assess joint laxity throughout pregnancy. The “fingertip to

81 floor test” is a little bit easier to spread than the “sit and reach test”. During the “fingertip to floor test”,  
82 the distance is indeed measured between the fingertip and the floor. During the “sit and reach test”, the  
83 distance is measured between the fingertip and a box. One has then to have an adequate box to be able to  
84 perform this test. However, a doubt remains about the ability for pregnant women to realize the “fingertip  
85 to floor test” at the end of pregnancy. The morphologic changes in terms of abdominal circumference,  
86 weight, and modification of the center of gravity position might indeed obstruct the ability to bend  
87 forwards as required by the “fingertip to floor test”.

88 In this study, we conducted a longitudinal monitoring of ligament laxity at a wide range of joints in  
89 pregnant women by combining an objective measure, the extensometer, that has been proven to be  
90 efficient to detect small changes in ligament laxity [1,19], and simple clinical tests. The aims of this study  
91 were to determine how laxity during pregnancy evolves and to propose a simple clinical methodology that  
92 could be used in daily practice helping to prevent pathologies associated with increase in laxity. An  
93 objective quantification of laxity could allow us to carry out further studies for a better understanding of  
94 the origins of back pain and pelvic floor disorders during pregnancy.

## 95 **2. MATERIAL AND METHODS**

### 96 ***2.1 Population***

97 Eligible participants were women with age over 18 years and with a BMI inferior to 40. None of the  
98 participants presented current or previous inflammatory joint disease affecting the integrity of the  
99 musculoskeletal system; hypermobility syndrome like Ehlers Danlos or Marfan syndrome. The control  
100 group was included to have a baseline value of the laxity before pregnancy. The Ethics Committee of the  
101 Poitiers Hospital and the National Agency of Drug Safety reviewed and approved this study protocol and  
102 each participant signed a written informed consent.

103 The metacarpophalangeal joint laxity, hip and lumbar flexibility and generalized joint laxity were  
104 measured in pregnant women at the first, second and third trimesters while women of the control group  
105 were tested only once.

106

## 107 **2.2 Metacarpophalangeal joint laxity assessment**

108 An extensometer of the metacarpophalangeal joint of the index was purpose-made (figure 1) according to  
109 Jobbins and colleagues principle [19]. The extension force applied on this joint was measured by a force  
110 sensor while the metacarpophalangeal joint angle and force direction derived from reflective markers  
111 captured by an optoelectronic motion system (Vicon Motion System Ltd). Force and kinematic data  
112 were synchronized using the Nexus Motion Capture Software (version 1.8.5). Specifically, participants  
113 were asked to sit comfortably in front of the extensometer and be relaxed. They put their index of the  
114 non-dominant hand in the extensometer interstice. The proximal portion of the metacarpus was  
115 immobilized to only measure the movement of the metacarpophalangeal joint of the index. One reflective  
116 marker was placed on the base of the finger and a second marker on the tip of the support of the  
117 extensometer to measure the metacarpophalangeal joint angle. Then the experimenter turned the rack  
118 slowly and continuously until the participant experienced discomfort. Based on the force, its direction and  
119 the metacarpophalangeal joint angle, the joint moment was calculated. From the time histories of both  
120 joint angle and moment, the angle obtained when the metacarpophalangeal joint underwent a moment of  
121 0.26 Nm was selected [1,19].

122

## 123 **2.3 Hip and lumbar flexibility tests**

124 The first measurement corresponded to the fingertip to floor test (F2F test). From a 20 cm high platform,  
125 women were instructed to reach the floor with their fingertips while keeping knees extended and feet  
126 together. The distance between the middle finger and the base of the platform was expressed in  
127 centimeters. A positive value corresponded to a position of the middle finger above the platform level and  
128 a negative value below (figure 2A).

129 The second measure was an adapted version of the “sit and reach test” that will be later referred to as the  
130 horizontal Sit and Reach test (hSR test). The acquisition was done on the delivery bed, where the woman  
131 was seated with legs straight. The participant maintained her arms horizontal and bent the trunk as much  
132 as possible. For this test, the distance between the middle finger and the vertical plane passing by the  
133 soles of the feet was measured (a negative value corresponding to a position of the middle finger that

134 exceeds the passing by the soles of the feet vertical plane, see figure 2B).In both tests, performance was  
135 measured by the optoelectrical system using markers placed on the foot soles and the right middle  
136 finger tip.

137

#### 138 ***2.4 Beighton score***

139 For each participant generalized joint laxity was also assessed using the Beighton score [20] as depicted  
140 on Figure 3. The laxity of nine joints was assessed using nine “all-or-nothing” tests (i.e. thumbs  
141 opposition, hyperextension of the 5th fingers, recurvatum of the elbows, hyperextension of the knees of  
142 the left and right sides, lumbar flexibility). The total score varies from 0 to 9 with high scores denoting  
143 more generalized joint laxity.

144

#### 145 ***2.5 Statistical methods***

146 For the statistical treatment, the normality of the distributions was confirmed by a Shapiro Wilk test.  
147 Differences for age, height, body mass and BMI between controls and pregnant women in the first  
148 trimester were examined using independent samples *t*-tests. During pregnancy, the trimester effect (three  
149 levels: first, second and third trimesters) was analyzed using a repeated measures analysis of variance  
150 (ANOVA). In case of significance, Tukey post hoc tests were performed to identify trimesters that were  
151 significantly different from each other. The effect size was calculated by dividing the difference between  
152 the means for the outcome variable by the pooled SD and was interpreted in accordance with Cohen's  
153 guidelines: 0.20 as small, 0.50 as moderate, and 0.80 as large. The correlations between the tests were  
154 studied using Pearson correlation coefficients. The significance level adopted was less than 0.05. All  
155 analyses were executed using the Statistica software (StatSoft, Tulsa, OK).

156

### 3. RESULTS

Seventeen pregnant women (age:  $36 \pm 2$  years, BMI<sub>1</sub>:  $24 \pm 3$  kg/m<sup>2</sup>, BMI<sub>2</sub>:  $25 \pm 3$  kg/m<sup>2</sup>, BMI<sub>3</sub>:  $27 \pm 3$  kg/m<sup>2</sup> at the first, second and third trimesters respectively including 6 primiparous and 11 multiparous) and sixteen controls (age:  $31 \pm 6$  years, BMI:  $21.3 \pm 1.6$  kg/m<sup>2</sup>) were recruited during a routine gynecological consultation at the University Hospital of Poitiers.

Regarding the anthropometric data, no significant differences between the control group and pregnant women in the first trimester were found for age ( $p = 0.35$ ) and height ( $p = 0.7$ ) as shown in Table 1. The body mass and BMI were significantly higher in pregnant women (all  $p = 0.01$ ).

All women were able to perform all of the laxity tests. However, three have reported discomfort in performing the F2F test. Joint laxity measurements are summarized in Table 2 and Table 3. No significant difference was found for all the laxity tests between the control group and pregnant women at the first trimester, except for the Beighton score ( $p = 0.02$ , Cohen's  $d = 0.80$ ), which was significantly higher in pregnant women (Table 2).

During the pregnancy (Table 3), the extensometer results showed a trimester effect ( $F(2, 32) = 4.88$ ,  $p = 0.018$ ). Tukey post hoc tests highlighted that the laxity was significantly smaller at the first trimester compared to the second ( $p = 0.024$ , Cohen's  $d = 0.5$ ) and the third ( $p = 0.033$ , Cohen's  $d = 0.5$ ). No significant change between the 2<sup>nd</sup> and 3<sup>rd</sup> trimester was observed ( $p = 0.917$ , Cohen's  $d = 0.0$ ).

As regards the results of the flexibility of the hip and lumbar, we observed a significant change during pregnancy for the fingertip to floor test ( $F(2, 32) = 3.78$ ,  $p = 0.034$ ) and the hSR test ( $F(2, 32) = 7.69$ ,  $p = 0.001$ ). The distance measured between the foot soles and the middle fingers tip was significantly greater at the third trimester of pregnancy compared to the first ( $p < 0.05$ ) and the second trimester ( $p < 0.05$ ) according to the results of post hoc tests. No difference between the first and the second trimesters was revealed for these two tests.

The Beighton score demonstrated statistically significant changes of generalized laxity during the course of the pregnancy ( $F(2, 32) = 4.75$ ,  $p = 0.029$ ). Post hoc tests revealed a significant increase at the second trimester ( $p = 0.024$ , Cohen's  $d = 0.6$ ) compared to the first trimester which decrease after at the third trimester ( $p = 0.017$ , Cohen's  $d = 0.8$ ).

184 Pearson correlation coefficients showed a moderate correlation between the results given by extensometer  
185 and the Beighton scores in the control group and pregnant women at the first trimester ( $r = 0.60$ ,  
186  $p < 0.05$ ). This correlation was low in pregnant women for the second and third trimester ( $r = 0.40$ ,  
187  $p = 0.02$ ). There was no correlation between joint laxity measured by the two hip and lumbar flexibility  
188 tests and the extensometer ( $p > 0.05$ ).

189

#### 190 **4. DISCUSSION**

191 Since laxity could be associated with development of different conditions such as back pain [7,8] or  
192 pelvic floor dysfunctions [28], it is important to find an assessment as simple as possible to enable its  
193 deployment in clinical settings for prevention and patients follow-up regarding the pre-cited conditions.  
194 To the best of our knowledge, this is the first study that confronts data from extensometer for longitudinal  
195 monitoring of metacarpophalangeal joint laxity among pregnant women with a series of complementary  
196 clinical measures of generalized laxity. Calguneri and colleagues used Jobbin's extensometer for pregnant  
197 women only between the third trimester of pregnancy (from 24<sup>th</sup> to 40<sup>th</sup> week) and after delivery [1].

198 Our results confirmed Calguneri's findings (1982) that metacarpophalangeal joint laxity evolved during  
199 pregnancy [1]. Our results showed that this peripheral laxity measured by the extensometer increased by  
200 11% from the first to the second trimester of pregnancy to keep the same level thereafter which reveals an  
201 important evolution of metacarpophalangeal laxity. We believe that these findings are of great interest for  
202 the management of conditions associated with increased laxity in pregnant women.

203 Compared with those of Calguneri and colleagues, the values obtained in the present study are smaller  
204 (around 40° in our study and around 65° for Calguneri and colleagues' study (1982)). This difference  
205 might be explained by the definition of the torque applied. Indeed, we sought to apply an external torque  
206 of 0.26 N.m at the metacarpophalangeal joint. To compute this torque, we took into account the finger  
207 weight by measuring the joint torque when horizontal. In the original publication by Jobbins and  
208 colleagues, it isn't clear whether the finger weight was taken into account or not and what exactly  
209 represents the external torque applied at the metacarpophalangeal joint [1,19].

210 Generalized joint laxity assessed by the Beighton score increased at the second trimester and was  
211 moderately correlated with the results given by the extensometer. Therefore, we concluded that laxity  
212 evolution is particularly widespread during the two first trimesters of pregnancy by affecting different  
213 joints of the body. However, the Beighton score decreased in the third trimester. This result may be due to  
214 the inability of women to perform the forward flexion of the trunk in a standing position (only 3/17  
215 participants were able to complete the 5th item) because of the abdominal volume which is higher in the  
216 third trimester and which could hamper the execution of this item. Overall, this test is simple to use and  
217 evaluates different type of joints. However, we believe that the use of this score to assess the evolution of  
218 laxity in pregnant women remains insufficient due to its lack of sensitivity to changes and to the  
219 aforementioned problematic of the forward flexion of the trunk with large abdominal volume. The score  
220 is indeed based on the sum of ones and zeros corresponding to the ability to reach or not specific joint  
221 postures. It is therefore necessary to improve the test interpretation. For instance, the negativity should  
222 not allow excluding the diagnosis of hyper laxity.

223 The Finger to Floor test and the Sit and Reach test are simple clinical tests to evaluate the flexibility in the  
224 hip and lumbar joints. These joints are thought to be more exposed to local changes of pregnancy (uterine  
225 weight, increased abdominal volume, advancement and lowering of the center of mass [29], balance  
226 alterations and increase of the risk of falls [30]). For this reason, we expected that the results from these  
227 tests would reflect the changes in joint laxity during pregnancy. However, our results do not confirm this  
228 hypothesis. For the Finger to Floor test, the distance measured between the fingertip and the horizontal  
229 plane passing by the sole of the feet increased during pregnancy when it should have been the opposite to  
230 reflect an increased hip/lumbar joint laxity. None of the pregnant women refused or even mentioned any  
231 apprehension to perform the test at the end of pregnancy. However, they often mentioned that the volume  
232 and the weight of the abdomen seriously hampered there realization of this test. In our study, the  
233 horizontal Sit and Reach was intended to anticipate that some women would refuse to perform the Finger  
234 to Floor test. The results indicated a reduction of the distance between the finger and the vertical plane  
235 passing by the soles of the feet during the first part of pregnancy compared to control group even though  
236 not significant and an increase at the third trimester. The increase in abdominal volume here again and the  
237 anterior shift in the location of the center of mass during pregnancy could explain the alteration of the

238 results of these tests[31]. In summary, evaluating the flexibility of the trunk by these two last tests or by  
239 the 5th item of the Beighton score do not seem suitable for pregnant women.

240 Regarding limitations, our study may be limited by the small sample size. Furthermore, the difference in  
241 age between the case group and the control group could have slightly influence on the results of laxity,  
242 while it has been cited that laxity changes inversely with age. However, according to the literature  
243 [32,33], this difference in age (only four years of average difference) is considered negligible to cause  
244 significant changes in laxity. Finally, the laxity measure was here based on the use of an optoelectronic  
245 capture system. A simplified version of the extensometer that doesn't require an optical motion capture  
246 system is been built.

247 In conclusion, metacarpophalangeal and generalized laxity increased considerably at the second trimester  
248 of pregnancy. According to Carvalho and colleagues low back pain is also more frequent in the second  
249 trimester of pregnancy [34] and pain in the hand and wrist is known to be the second most prevalent  
250 musculoskeletal symptom during pregnancy [10]. These concomitant findings indicate the need for  
251 prevention strategies that enable better quality of life for pregnant women. The combination of an  
252 objective measurement by the extensometer and a global evaluation of the laxity by the Beighton' score  
253 may be useful for a daily assessment of laxity in order to establish a specific laxity profile based on which  
254 we can choose a special monitoring for pregnant women.

255 These results will be reinvested by two adjacent studies: a first study analyzing the eventual relationship  
256 between ligament laxity and pelvic floor disorders in pregnant women and a second one interested in the  
257 prevalence of lumbar lordosis in pregnant women.

258

## 259 **Conflict of interest statement**

260 The authors have no conflict of interest.

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262 **Table 1:** Participant anthropometric characteristics (mean  $\pm$  standard deviation) and *p* values of  
 263 the comparisons between the control group and pregnant women at the first trimester (PW1).

	<b>Control (n=16)</b>	<b>PW1 (n=17)</b>	<b><i>p</i> value</b>
<b>Age (years)</b>	31.7 $\pm$ 6.3	35.8 $\pm$ 1.8	0.35
<b>Height (m)</b>	1.64 $\pm$ 0.06	1.65 $\pm$ 0.05	0.74
<b>Body Mass (kg)</b>	57.3 $\pm$ 5.3	64.2 $\pm$ 7.9	0.01*
<b>BMI (kg/m<sup>2</sup>)</b>	21.3 $\pm$ 1.6	23.7 $\pm$ 2.9	0.01*

264

265 **Table 2:** Results (mean  $\pm$  standard deviation) of all tests (extensometer, F2F test, hSR test,  
 266 Beighton score) of the control group and pregnant women at the first trimester of pregnancy  
 267 (PW1)

	<b>Control</b>	<b>PW1</b>	<b><i>p</i> value</b>	<b>Effect size</b>
<b>Extensometer (degree)</b>	38.6 $\pm$ 7.4	40.8 $\pm$ 8.7	0.412	0.30
<b>F2F test (cm) (n with distance <math>\leq</math>0)</b>	1.8 $\pm$ 15.7 (n = 10)	7.2 $\pm$ 11.4 (n = 4)	0.050	0.40
<b>hSR test (cm)</b>	-2.2 $\pm$ 10.8	-4.5 $\pm$ 9.7	0.751	0.22
<b>Beighton score (n with score <math>\geq</math>4/9)</b>	1.8 $\pm$ 1.5 (n = 2)	3.5 $\pm$ 2.6 <sup>c</sup> (n = 10)	0.022*	0.80 <sup>b</sup>

268 **NOTE:** <sup>c</sup> statistically significant compared with the control group; *p* < 0.05. \*, *p*<0.05;  
 269 a, moderate effect size; b, large effect size.

270

271 **Table 3:** Results (mean  $\pm$  standard deviation) of all tests (extensometer, F2F test, hSR test,  
 272 Beighton score) of pregnant women for the three trimester of pregnancy (PW1, PW2 and PW3)

	<b>PW1</b>	<b>PW2</b>	<b>PW3</b>	<b><i>p</i> value</b>	<b>Effect size</b>	<b>Observed power</b>
<b>Extensometer (degree)</b>	40.8 $\pm$ 8.7	45.5 $\pm$ 11.2 <sup>1</sup>	45.1 $\pm$ 9.7 <sup>1</sup>	0.018	0.40	0.7
<b>F2F test (cm) (n with distance <math>\leq</math>0)</b>	7.2 $\pm$ 11.4 (n = 4)	8.3 $\pm$ 13.8 (n = 5)	12.1 $\pm$ 11.5 <sup>1,2</sup> (n = 3)	0.012	0.20	0.8
<b>hSR test (cm)</b>	-4.5 $\pm$ 9.7	-3.3 $\pm$ 9.2	4.5 $\pm$ 7.2 <sup>1,2</sup>	0.001	0.50	1.0
<b>Beighton score (n with score <math>\geq</math>4/9)</b>	3.5 $\pm$ 2.6 (n = 10)	5.2 $\pm$ 2.8 <sup>1</sup> (n = 12)	3.1 $\pm$ 2.4 <sup>2</sup> (n = 6)	0.029	0.40	0.7

273 **NOTE:** <sup>1, 2</sup> statistically significant compared with the first and second trimester value  
 274 respectively (*p*<0.05).

275

276

277

278 **Figure 1:** Installation of the patient's hand inside of the extensometer which is equipped with  
279 reflective markers and a force sensor (ELPF-T3M-500N, Sensix, France) allowing to measure  
280 the angle in function of the applied torque to the metacarpophalangeal joint.

281

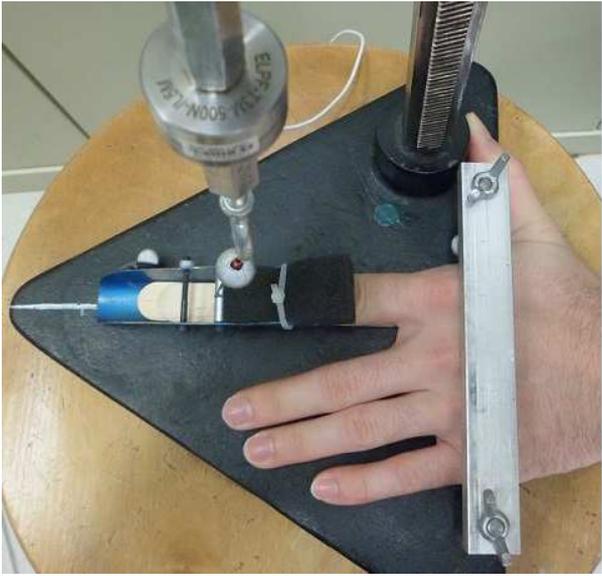
282 **Figure 2:** (A) Classical version of Finger to floor test; (B) Sit and reach test (hSR test). For  
283 these two tests, reflective markers are placed at the tip of the 3rd finger of the right hand, the  
284 external malleolus, heels and the bases of the 2nd metatarsal. Distance measured between the  
285 marker placed at the tip of the finger and the horizontal plane passing by the soles of the feet.  
286 Negative value is obtained when below.

287

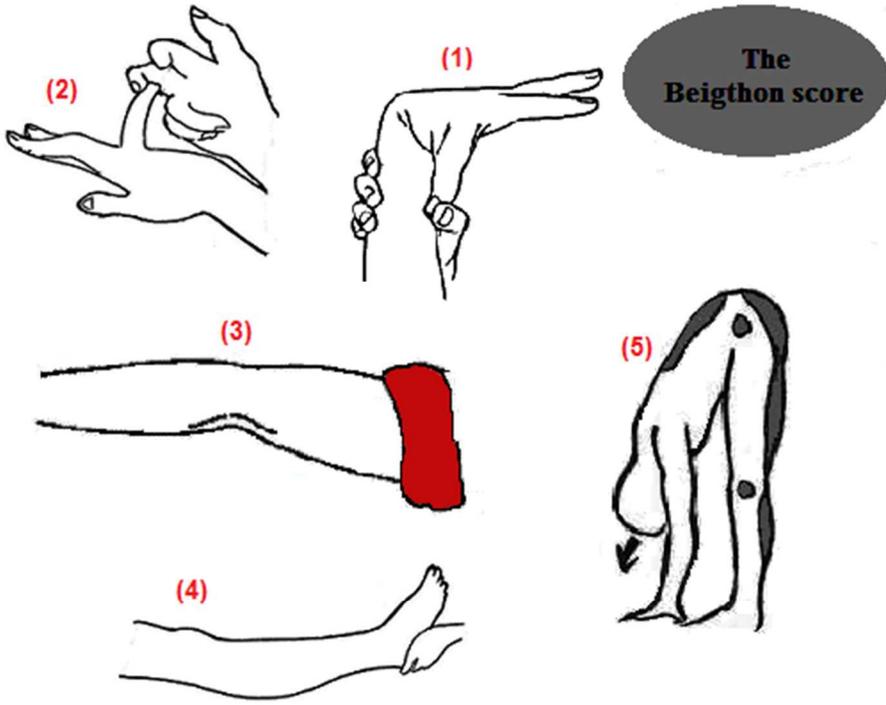
288

289 **Figure 3:** The Beighton score. The figure was taken from the Hypermobility Syndromes  
290 Association.

291







	Unable to perform (0 Points)	Able to perform (1 Points)
1. Passive apposition of thumb to forearm		
Right	0	1
Left	0	1
2. Passive hyperextension of fifth finger > 90 degrees		
Right	0	1
Left	0	1
3. Active hyperextension of elbow > 10 degrees		
Right	0	1
Left	0	1
4. Active hyperextension of knee > 10 degrees		
Right	0	1
Left	0	1
5. Forward flexion of trunk, legs straight, palms touching floor	0	1
<b>Total Beighton Score (Sum of points for each maneuver)</b>		<b>0 to 9 points</b>