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1	The measurement	of interface	pressure	applied	by sports	compression	garments: a
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2 comparative study of two portable devices

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- 5 Authors: Chris McManus<sup>1</sup>, Prabhuraj D. Venkatraman<sup>2</sup>, Gavin Sandercock<sup>1</sup>,
- 6 Affiliations: <sup>1</sup>School of Sport, Rehabilitation and Exercise Sciences, University of Essex,

7 Colchester, UK

- 8 <sup>2</sup>Manchester Fashion Institute, Manchester Metropolitan University, Manchester, UK
- 9 Corresponding Author: Chris J McManus, University of Essex, School of Sport,
- 10 Rehabilitation and Exercise Sciences, Wivenhoe Park, CO4 3SQ, Essex, UK. Tel: +44 1206
- 11 874475. cmcman@essex.ac.uk
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# 21 Abstract

22 The interface pressure applied by compression clothing is an important measure in evaluating 23 the efficacy of the bio-physical impact of compression. The aim was to compare two portable 24 pneumatic pressure measuring devices (PicoPress and Kikuhime), against a non-portable, 25 Hohenstein System (HOSY) reference standard, used by medical regulatory agencies. 26 Interface pressure obtained in-vivo (calf) by the PicoPress and Kikuhime, were compared 27 with HOSY. The mean bias and limits of agreement indicate the PicoPress satisfies the a 28 priori thresholds for acceptable validity at the posterior and lateral orientation with calf 29 stockings (-0.4[-3.3;2.5]; 0.5[-3.4;4.4] mmHg) and tights (0.2[-4.7;5.1]; 1.2[-0.3;5.4] mmHg) 30 respectively. The Kikuhime did not satisfy thresholds for acceptable validity at any 31 orientation, overestimating the pressure compared with HOSY. We recommend using the 32 PicoPress, specifically at the posterior or lateral aspect of the calf. This is of particular 33 relevance when the hosiery is applying relatively low levels of pressure, applicable to sports 34 compression.

35

36	Keywords:	pressure device,	compression	clothing, mea	asurement and	verification,	bias
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37 validity

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#### 43 Introduction

Compression garments are popular clothing choices among recreational and professional
athletes during and after exercise. These garments have been shown to enhance athletic
performance and accelerate recovery following strenuous exercise (Hill et al. 2014, Engel et
al. 2016).

48 Despite the prospective benefits, little is known regarding the optimal 'interface-pressure' a 49 compression garment should apply to a particular limb, to produce the greatest athletic 50 benefit(Brophy-Williams et al. 2013). In contrast, the application of pressure to the lower 51 extremities via tight fitting, elastic garments, is extensively researched in the clinical field 52 and is part of standard care in patients with chronic venous insufficiency and lymphatic 53 disease (Partsch 2012). Unlike sports compression garments, medical compression stockings 54 undergo a standardised assessment procedure to quantify the pressure applied; therefore 55 recommendations can be made in relation to the treatment protocol including a desired 56 interface pressure (Stout et al. 2012). Such recommendations cannot be made with regard to 57 athletic performance or recovery due to a number of methodological limitations. 58 Heterogeneity of published literature relating to research design is commonplace, including 59 but not limited to; variation in garment design, duration of wear, type of garment and limb 60 coverage. Furthermore, authors fail to measure the pressure of garments (Ménétrier et al. 61 2011) or values are provided by the garment manufacturer and are not directly measured (7). 62 If garment pressure is reported, the measurement devices used by researchers vary greatly, 63 ranging from portable units and force-transducers to medical-grade devices. Until the 64 measurement of the interface pressure elicited by sports compression garments is 65 standardised, developing a consensus and furthering the field regarding dose-response will continue to be a challenge. The reporting of pressure, obtained directly by research scientists 66 67 and clinicians would progress the field of sports compression and enable the investigation of

optimal interface pressures (dosage) and gradients required for improved performance and
 recovery outcomes (Brophy-Williams et al. 2013).

A critical aspect of effective compression therapy is that the appropriate level of pressure is
applied to the limb. Portable pressure sensing devices offer quick, low cost, *in-vivo*assessment during dynamic movement. Validation of measures made *in-vivo* by these devices
is necessary to establish preferable devices and inform best practice.

74 Current guidelines for the assessment of *in-vivo* interface pressure list 22 portable devices

75 (Partsch et al. 2006), including pneumatic, piezoelectric, resistive and capacitive sensors. The

authors state that the quantification of interface pressure will enable comparisons between

clinical trials to assess dosage and the correlation with clinical and physiological

measurements. However, many of the portable devices listed in the guidelines have not been

validated nor compared with alternative methods of pressure assessment i.e. fixed, non-

80 portable reference devices.

Portable devices must undergo rigorous assessment to identify if variation exists between units. Furthermore, the accuracy of these devices versus a clinically relevant reference standard is necessary to provide a comparative assessment of performance. By identifying portable devices with acceptable accuracy, guidelines can be developed further and ultimately assist with understanding the bio-physical impact of interface pressure on physiological response and performance outcomes.

In light of this, we assessed the criterion validity of interface pressure measures from two
commercially-available devices *in-vivo* by comparing pressure measurements against a
reference standard.

90

#### 91 *Methods*

92 We compared two portable devices (Kikuhime and PicoPress) commonly used with a 93 'reference standard' system (HOSY). The HOSY is a mandatory testing system for interface 94 pressure compliance, required for the classification and certification of medical compression 95 hosiery. Two warp knitted compression garments were used, including calf- stockings, 96 covering the ankle to below the knee and full-length tights, covering the body from ankle to 97 waist. The fabric properties of the two compression garments were investigated for 98 performance including fabric weight using Sartorius balance. Fabric thickness was measured 99 using a Shirley thickness gauge (Mitutoyo, Japan) (BS EN ISO 5084 1997). Fabric count 100 (number of wales and courses) was measured with a simple eye piece lens that had 5x 101 magnification. Stretch and recovery was also evaluated to determine the stretch 102 characteristics of fabric in length and cross wise direction using Fryma Extensiometer (BS 103 EN ISO 4294 1968) and 3 kg load was applied (Table 1). All fabrics were conditioned in 104 standard laboratory conditions ( $20 \pm 2^{\circ}$ C,  $65 \pm 0\%$  relative humidity) for 24 h prior to the 105 fabric tests (BS EN ISO 139 2005). Garments did not undergo pre-treatment washing prior to 106 or between measurements.

107

```
108 ****Table 1 ****
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109

# 110 **Reference Standard Device**

# 111 The Hohenstein System (HOSY, Bönnigheim, Germany) is used to measure interface

- 112 pressure and determine if garments meet the German 'medical compression hosiery'
- standards RAL GZ 387/1,2 (RAL-GZ 387/1 2008). The HOSY measures interface pressure
- 114 (maximum resolution of 0.01 kPa), wear stretch (elongation %), tensile force (N/cm) and

residual pressure (%). The device (Figure 1) comprises twenty individual tensile testing
'rods', each with a width of 50 mm. The force measurement takes place at the fixed clamp
rod via short-distance electronic transducers. The measurement principle of the HOSY is
based on the force exerted by compression fabric in circumferential direction, when stretched
in a longitudinal direction to a specified length and subsequently in a transverse direction
according to its size. For further details of the HOSY see the RAL GZ 387/1 standards (RALGZ 387/1 2008).

# 122 Calibration

123 Pressure was measured on both garments at the location that corresponded with the maximum 124 calf girth. The maximum calf girth (commonly referred to as 'location C' in published 125 guidelines (Partsch et al. 2006) and standards (RAL-GZ 387/1 2008) was chosen as interface 126 pressures exerted in this region are commonly cited in both medical (Mosti and Partsch 2013) 127 and sports compression literature (Dascombe et al. 2011). Prior to the measurement process, 128 the ankle location (also referred to as 'location B') was manually identified on both garments 129 and subsequently location C is marked at a height of 200 mm above this point. Calibration of 130 the HOSY device takes place annually by attaching a 5 kg weight to each of the 20 tensioning 131 clamps.

# 132 Reference Standard Protocol

A qualified technician attached the garments and operated the HOSY device in a controlled laboratory environment  $(18 \pm 0^{\circ}C, 65 \pm 0\%)$  relative humidity). Briefly, two clamps held the bottom of the garment in place (Fig 1.a) with the remaining garment placed in each fixed clamp rod (Fig 1.b). Once correctly fastened into the HOSY, the distance of location C (Fig 1.c) from the bottom clamps was entered into the operating computer. The garment was stretched (loaded) and relaxed (unloaded) six times in the cross-wise direction. Each loading

139 cycle extended the garment to the leg circumference. During the final loading phase the tensile force at each clamp was measured. The computer program calculates how far each 140 141 tensioning clamp moves to achieve the desired circumference and the resultant elongation of 142 the hosiery so that all clamps reach this position simultaneously after 20 seconds (RAL-GZ 387/1 2008). A minimum and maximum leg circumference of 370 and 400 mm at Location C 143 144 was used for this investigation. Initially, the test-retest reliability of the HOSY was 145 determined by measuring the tights twice. Between each assessment, the garment was 146 unclamped and removed from the HOSY and reapplied by a qualified technician. The 147 technical error of measurement (TEM) and coefficient of variation (CV) reported for the 148 HOSY was 0.5 mmHg and 5.8% respectively. For all data analysis referring to the tights, the 149 mean of the two repeated measures at minimum and maximum elongation was used. Calf 150 stockings were measured on one occasion only.

151 Compression classification standards vary by country (Neumann et al. 2016, Nicolaides et al. 152 2018) but a unified classification of mild (10-19 mmHg) and moderate (20-29 mmHg) 153 compression is proposed. With this in mind, when comparing portable devices with the 154 reference standard and determining device validity, a priori thresholds are required. The 155 criteria for acceptable validity was defined as a systematic bias of  $\pm 2$  mmHg and a limit of 156 agreement  $\pm 5$  mmHg (of the mean bias). A bias of  $\pm 2$  mmHg accounts for technical error of 157 the HOSY and the resolution of the portable devices. Limits of agreement of  $\pm 5$  mmHg identify the variability of the device vs. the reference standard accounting for the 10 mmHg 158 159 classification range.

160

161 **\*\*\*\*Figure 1 \*\*\*\*** 

#### 163 **Portable Devices**

164 The PicoPress (Microlab, Padua, Italy) is a battery-operated device and comprises a 50 mm 165 circular sensor manufactured from 200  $\mu$ m thick flexible plastic tubing attached to the base 166 unit. The Kikuhime (Meditrade, Soro, Denmark) comprises 30 x 38 mm oval sensor made 167 from 3 mm polyurethane foam and connected to a transducer via silicone tubing. Both the 168 PicoPress and Kikuhime operate through pressure being applied to the sensor, thereby 169 displacing the air and acting on the pressure transducer housed in the battery-operated units. 170 The PicoPress can measure pressure up to 189 mmHg; and the Kikuhime up to 120 mmHg both with a resolution of 1 mmHg 171

## 172 Calibration

We calibrated devices according to the manufacturers' instructions. A self-calibration procedure is performed when switching the PicoPress unit on. Digital prompts on the device outline the calibration procedure by inserting 2 ml of air into the sensor, setting the unit to read 0 mmHg when hanging freely. In the same position, the Kikuhime requires the user to manually zero the potentiometer. In light of the Kikuhime calibration method and unit resolution, there is an inherent calibration offset error of up to  $\pm$  0.49 mmHg (Thomas 2014).

#### 179 **Portable Device Protocols**

#### 180 Water-column method

181 To certify measurement validity and linearity from air-filled portable pressure systems such 182 as the PicoPress and Kikuhime devices, the water column method provides a quick and in-183 expensive method making use of hydrostatic pressure.

184 As previously described (Brophy-Williams et al. 2013), by placing the pressure sensor flat at

185 the bottom of a water column, and filling the column with a specific volume of fluid, a

186 known pressure will be placed on the sensor. Water depths were calculated to determine 187 incremental pressures of 5 mmHg, from 5 to 25 mmHg, whereby the depth measurement was 188 taken from the lowest point of the meniscus and the middle of the sensor. The depth of water 189 (mm) to achieve the target pressures was calculated using the following equation,

190 
$$a \text{ mmHg} = b \text{ mmH}_2\text{O x} [7.356 \text{ x } 10^{-2}]$$

191 Five repeated measures were undertaken for each depth, which required the removal of water192 from the column each time, before returning it to achieve the predetermined depth.

# 193 In-vivo protocol

Twelve recreationally active males (mean  $\pm$  SD: age 19.1  $\pm$  1.0 y, body mass 74.6  $\pm$  4.8 kg, stature 1.77  $\pm$  0.05 m) gave written informed consent to participate in the study in accordance with Declaration of Helsinki. The ethical committee at the University of Essex approved the current investigation.

198 All testing was performed in a controlled laboratory environment ( $18 \pm 0^{\circ}$ C,  $50 \pm 2\%$  relative 199 humidity). Upon arrival, the circumference of the participants calf was measured (location C 200  $= 380 \pm 12$  mm). All participants possessed a maximum calf girth between 370 and 400 mm. 201 To ensure that garment Location C was accurately positioned at the correct limb height in-202 situ, position-markers on each garment were aligned with anatomical markings at the 203 maximal calf-girth. The anterior, posterior, medial and lateral aspect were identified with a 204 segmometer (Cescorf, Porto Alegre, Brazil). Limb width was measured at each orientation 205 and the mid-point marked as the location for the portable device sensor. Using the PicoPress 206 and Kikuhime devices, interface pressure at the anterior, posterior, medial and lateral aspect 207 around the maximum calf girth was measured. The investigator placed the air-filled sensor of 208 each device between the garment and skin, ensuring that the sensor remained flat.

209 Participants stood upright with feet shoulder width apart during all measurements. Garment 210 order was determined using a balanced two-Latin square design to minimize device and 211 orientation order effect. For each anatomical site, three repeated measures were obtained at 212 30-second intervals.

### 213 **Portable Devices Data Treatment**

214 *In-vivo* interface pressures were measured at four anatomical orientations and a fifth value 215 calculated as the average of all four measures (i.e. lateral + medial + anterior + posterior / 4 = 216 mean of four orientations ( $\overline{x}$ )). A Pearson's Product Moment correlation was used to 217 analyse the linearity of the PicoPress and Kikuhime against the water column reference 218 values. Data analyses were conducted using Graphpad Prism 7 (Graphpad Software, San 219 Diego, California) and reported as mean ± standard deviation (SD) unless otherwise stated.

#### 220 Data Analysis Agreement

221 Prior to comparing *in-vivo* portable devices with a reference standard, interface pressures 222 must be established for each participant for the reference device. The HOSY does not 223 measure pressure directly applied to the individual, instead, pressures are determined by 224 elongating the garment to a pre-determined length, simulating the circumference of a limb. 225 Therefore, a simple linear regression was calculated to predict interface pressure based on the 226 HOSY pressure values at minimum and maximum elongation. As the theoretical 227 circumference increased by 10 mm, interface pressure applied by the stockings increased by 228 0.86 mmHg between 370 and 400 mm (19.3 – 21.9 mmHg; y = 0.87x - 12.77). The interface 229 pressure of the tights increased 0.62 mmHg for every 10 mm increase in circumference (12.5 230 -14.4 mmHg; y = 0.62x - 10.32). The regression equation was then used to determine 231 individualized pressure from the reference standard by factoring the individuals' calf 232 circumference. Calculation of the estimated HOSY interface pressure for each participant

233 produced a mean [95% CI] pressure of 20.1 mmHg [19.5, 20.8] and 13.1 mmHg [12.6, 13.6] 234 for the stockings and tights respectively. Having established reference values, comparisons 235 can now be made with the portable, in-vivo devices. Normalcy was assessed using the 236 Kolmogorov-Smirnov test. The difference between the individualised HOSY values and 237 portable device pressures were assessed for significance using a one-sample t-test (target 238 value = 0). The method proposed by Bland and Altman (Bland and Altman 1986) was used to 239 assess agreement between the HOSY and each portable device at all anatomical orientations 240 The difference between devices was calculated as the interface pressure (mmHg) of the 241 HOSY minus the portable device (PicoPress or Kikuhime), therefore providing bias values 242 and upper and lower limits ( $\pm$  1.96 SD). Difference was plotted as a function of the HOSY 243 reference value (Krouwer 2008) and linear regression used to calculate slope (B) of the 244 HOSY versus portable device interface pressure. Analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 25 (SPSS Inc., Chicago, Illinois) 245 246 and the level of significance was set at  $\alpha = 0.05$ .

247 Results

The PicoPress and Kikuhime interface pressures produced a positive correlation when compared with the criterion water pressure. Correlation coefficients calculated to evaluate the linear association between the pressure applied by the water column and two portable pressure devices are shown in Figure 2.

252

253 \*\*\*\***Figure 2** \*\*\*\*

The interface pressures obtained by the reference standard, PicoPress and Kikuhime for the stockings and tights are shown in Table 2 and 3 respectively.

257 The PicoPress produced values which agreed with the reference standard when measured at

the posterior (-0.4 [-3.3; 2.5] mmHg) and lateral (0.5 [-3.4; 4.4] mmHg) orientations (Table

259 2). The positive mean bias values for measures at the anterior and medial orientation (Table

260 2) show PicoPress produced systematically higher values when compared with the reference

standard, Table 2 shows the Kikuhime produced values that were significantly higher

262 (P<0.01) compared with the reference standard at all measurement orientations, with a bias

263 ranging from -6.1 - -17.6 mmHg.

Table 3 shows the between-device agreement for tights. When compared with the reference standard, the PicoPress (Table 3) produced significantly higher values at the anterior orientation (P<0.01), but not at the posterior, medial and lateral orientation. Of the

267 orientations, the posterior, lateral and mean satisfied the *a priori* thresholds for acceptable

268 validity, reporting a bias of 0.2 [-4.7; 5.1], 1.2 [-0.3;5.4] and -0.6 [-4.5; 3.4] mmHg

269 respectively. The Kikuhime produced interface pressure values that were higher than the

270 HOSY. Regardless of orientation the Kikuhime had a mean bias >2 mmHg at all orientations

271 other than the medial aspect. At the medial orientation, the mean bias was 2.0 mmHg but the

272 limits of agreement were unacceptably wide and did not satisfy the validity threshold.

Of all the measurements obtained using both portable devices, the unstandardized slope
coefficient produced values ranging from -.02 – 2.4. With the exception of the posterior
orientation using the Kikuhime with calf stockings, all remaining slopes were positive. At the
posterior and lateral orientation, the PicoPress satisfied the validity thresholds with both
garments, demonstrating a small bias, acceptable limits of agreement and a negligible slope.

278 This means the PicoPress, at two specific orientations, is an accurate proxy measure for

279 interface pressure when compared with the reference standard.

280

281 \*\*\*\***Table 2** \*\*\*\*

282

283 \*\*\*\***Table 3** \*\*\*\*

284

## 285 Discussion

286 We investigated the validity of two portable pressure measurement devices. First, pressure 287 values reported by two portable devices were compared with hydrostatic pressure using a 288 water column method. Second, the two portable pressure devices were compared against 289 reference standard values analogous to those used to determine the classifications of medical 290 compression hosiery. In agreement with previous studies using the water column method 291 (Van den Kerckhove et al. 2007, Brophy-Williams et al. 2013, Chassagne et al. 2015) we 292 confirmed the Kikuhime and PicoPress devices produced reliable in-vitro measures of 293 hydrostatic pressure (Figure 2). However, this method in isolation does not ensure validity 294 in-vivo as measurement error is the sum of instrumental error and the geometry / mechanical 295 properties of the interface surface. The water column method is undertaken with the sensor in 296 a flat position, whereas *in-vivo* measures are commonly taken at locations where the surface 297 is curved, potentially impacting upon the pressure sensor performance (Thomas 2014). At 298 best, this technique offers the user a simple tool to assess unit precision and identify if 299 inherent malfunctions with the pressure device exist. However, the water column method

300 should not be used in isolation to determine the performance of a portable pressure monitor301 and its comparability with alternative garment pressure sensing devices.

302 The present *in-vivo* assessment confirmed the extent to which the point pressures vary at 303 different orientations. The results are similar to that previously reported, in that interface 304 pressure at the anterior orientation of the lower leg is greatest (Veraart et al. 1997, Liu et al. 305 2006, Rong et al. 2007). This is likely due to variation in the anatomic structure and shape of individual human legs. According to Laplace's law, the pressure exerted by a compression 306 307 garment is inversely proportional to the radius of curvature at a given location. It therefore 308 follows that pressure applied at the tibialis anterior muscle will result in the highest 309 circumferential pressure due to a smaller radius of curvature, when compared with the larger 310 radius of the gastrocnemius (medial, lateral and posterior location).

311 The PicoPress showed acceptable agreement for posterior and lateral measures of interface 312 pressure made in both garments. This prominent finding regarding device performance and 313 location of assessment is important to advance the standardisation of compression testing. In 314 contrast, the Kikuhime overestimated interface pressures in both garments and at all 315 anatomical sites. Under a sphygmomanometer cuff at 20 mmHg, the Kikuhime has 316 previously reported a pressure ~25 mmHg (Mosti and Rossari 2008). The Kikuhime systemic 317 overestimation of interface pressure may misclassify compression hosiery. . However, at 30 -318 50 mmHg both devices reported accurate and matching values (Mosti and Rossari 2008). 319 The validity of devices at lower pressures is important when assessing sports compression 320 garments which typically produce interface pressures of  $\sim 10 - 30$  mmHg (Beliard et al. 2015, 321 Hill et al. 2015). Differences in the size and shape of the air-filled sensors used in both 322 devices might explain the observed bias. The PicoPress uses a circular sensor 40 mm in diameter whereas the Kikuhime uses smaller (38 x 30 mm) oval sensors with a smaller area 323 324 (895 mm<sup>2</sup>). When placed on a cylindrical shape, a smaller sensor will result in a reduced

radius of curvature, possibly explaining the higher interface pressures reported by theKikuhime.

327 The Kikuhime sensor is also 2 mm deeper than the PicoPress when inflated and also includes 328 a foam insert. The increased depth of the Kikuhime creates a local protuberance when used 329 *in-vivo*. Any additional protrusion will distend the fabric of tight fitting garments causing an 330 increase in tension and the sensor bulge will reduce the radius of curvature and result in a 331 further increase in observed interface pressure (Vinckx et al. 1990). 332 The *B* slope coefficient is a product of the calculated HOSY values and compared with the 333 interface pressure obtained with a portable device. The PicoPress values at the posterior and 334 lateral orientation for both garments report a low, positive B slope (<1.5 mmHg). The 335 positive slopes indicate that at the lower end of the reference standard interface pressure, the 336 portable devices report a higher value, whereas at the higher end of the reference standard 337 pressure, the portable devices tend to underestimate interface pressures. The current results are a product of the garment and device interaction whereby the specific 338 339 garment fabrics have shown to play a pivotal role in altering the interface pressure. The 340 garments used in the present study, whilst commercially available, do not reflect the wide range of fabric compositions used for sport and medical compression and therefore caution 341 342 should be used to extrapolate the present findings across alternative fabrics. Future research

343 should compare the interface pressure reported by portable pressure devices with

344 compression garments of a known pressure (i.e. 10, 20 and 30 mmHg). By using the

345 PicoPress at the approved orientations, it will provide insight into the variability of pressure

346 when off-the-shelf garments are measured.

The PicoPress and Kikuhime are commonly cited devices in medical literature (Mosti et al.
2009, Schuren et al. 2010), sub-bandage pressure assessment (Mosti and Partsch 2010,

349 Weller et al. 2010), and as reference devices in the development of piezoresistive sensors 350 (Chi et al. 2017). However, in the current study, and in agreement with previous research 351 (Mosti and Rossari 2008, Partsch and Mosti 2010, Thomas 2014), significant discrepancies 352 between the devices are evident. However, this study not only reports differences between 353 portable devices, but also compares performance with a reference standard. This study 354 contributes towards international standardization by identifying a portable pressure sensor 355 (PicoPress) and assessment location (posterior and lateral) capable of replicating pressure 356 values established from a reference standard. This is an important finding given the low-cost 357 and speed in which garment pressure can be determined using a portable pressure monitor 358 when compared with indirect methods. These findings are particularly relevant for 359 researchers, garment designers and clinicians monitoring garment pressure, when interpreting 360 the pressure applied in a wider context and comparing with the standardised pressure 361 classifications.

## 362 Conclusion

Two portable pressure devices were rigorously assessed in order to contribute much needed future standardization of pressure evaluations for sports compression. When compared with a reference standard, the PicoPress provides a valid measure of interface pressure at the posterior and lateral location of the calf. From a practical, *in-vivo* standpoint, we recommend using the PicoPress to assess interface pressure, specifically at the posterior or lateral aspect of the calf. This is of particular relevance when the hosiery is applying relatively low levels of pressure, applicable to sports compression.

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380	Conflict of interest
381	The authors have no conflicts of interest
382	
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478	Figure 1. The Hohenstein System (HOSY) showing (a) clamps holding the bottom of the
479	garment, (b) 20 measuring rods with clamps and (c) measurement tape.



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490	Figure 2. Linearity and correlation coefficients for the (a) PicoPress and (b) Kikuhime
491	device.





	Weight	Thickness	Composition	Count	Extension	Residual
	$(g/m^2)$	(mm)		(wpc x	(%)	extension
				cpc)		(%)
Stockings	298	0.69	65% Nylon	420 x		
	(2.83)	(0.00)	35% elastane	250		
Length					52.67	2.67
wise					(0.94)	(0.00)
Cross					96.67	2.00
wise					(4.71)	(0.94)
Tights	199.33	0.57	76% Nylon	520 x		
	(0.57)	(0.01)	24% elastane	500		
Length					164.89	8.0
wise					(13.87)	(3.52)
Cross					94.67	2.67
wise					(2.67)	(1.33)
Number in	the bracket	ts indicates st	andard deviation	n; cpc – cou	urses per mm;	wpc – wales
per mm						
<b>Fable 2</b> . Int	erface press	sure, significa	ince, agreement	values (bias	s and limits) an	id slope
oetween HC	SY and po	rtable devices	s with stockings			

	Interface	Л		
	Pressure	<i>P</i> -	Bias [95% LoA]	<i>B</i> [95% CI]
	(mmHg [SD])	value		
Orientation	PicoPress			
Anterior	29.3 [3.9]	< 0.01	-9.2 [-1.8; -0.6]	2.4 [0.0 - 4.8]
Posterior	20.6 [1.5]	0.35	-0.4 [-3.3; 2.5]	0.5 [-0.4 - 1.4]
Medial	22.0 [2.1]	0.02	-1.8 [-6.5; 2.8]	1.1 [-0.3 – 2.5]
Lateral	19.6 [2.1]	0.37	0.5 [-3.4; 4.4]	0.4 [-0.9 – 1.7]
$\overline{x}$	22.9 [1.5]	< 0.01	-2.7 [-6.4; 0.9]	1.1 [0.1 – 2.0]
	Kikuhime			
Anterior	37.7 [4.4]	< 0.01	-17.6 [-26.8; -8.3]	1.7 [-1.2 – 4.6]
Posterior	26.2 [3.0]	< 0.01	-6.1 [-11.4; -0.8]	-0.2 [-1.9 –1.6]
Medial	27.0 [3.8]	< 0.01	-6.9 [-15.0; 1.2]	1.5 [-1.0 – 4.0]
Lateral	26.5 [3.8]	< 0.01	-6.3 [-14.3; 1.6]	1.3 [-1.2 – 3.8
$\overline{x}$	29.4 [2.5]	< 0.01	-9.2 [-14.6; -3.9]	1.1 [-0.5 – 2.7]

 $\overline{x}$  = mean of four orientations; SD = standard deviation; LoA = limits of agreement; *B* = unstandardized beta coefficient of regression slope; CI = confidence interval. Mean [95% CI] HOSY pressure = 20.1 [19.5, 20.8] mmHg.

	Interface			
	Pressure	P-value	Bias [95% LoA]	<i>B</i> [95% CI]
	(mmHg [SD])			
Orientation	PicoPress			
Anterior	16.9 [2.9]	<0.01*	-3.8 [-10.1; 2.5]	2.0 [-0.6 - 4.7]
Posterior	12.9 [2.3]	0.82	0.2 [-4.7; 5.1]	1.3 [-0.9 – 3.4]
Medial	13.0 [2.7]	0.93	0.1 [-5.8; 6.0]	2.2 [-0.2 – 4.6]
Lateral	11.9 [1.9]	0.07	1.2 [-3.0; 5.4]	1.3 [-0.5 – 3.1]
A	13.7 [1.6]	0.35	-0.6 [-4.5; 3.4]	1.7 [0.3 – 3.1]
	Kikuhime			
Anterior	21.0 [4.4]	<0.01*	-7.9 [-16.7; 1.0]	1.2 [-2.9 – 5.3]
Posterior	15.9 [2.2]	<0.01*	-2.9 [-7.0; 1.3]	0.2 [-1.8 – 2.2]
Medial	15.1 [3.4]	0.69	-2.0 [-8.6; 4.7]	0.6 [-2.5 – 3.8]
Lateral	15.1 [2.6]	0.03*	-2.1 [-7.4; 3.3]	1.2 [-1.2 – 3.6]
А	16.8 [2.1]	<0.01*	-3.7 [-8.1; 0.7]	0.8 [-1.2 – 2.8]

**Table 3.** Interface pressure, significance, agreement values (bias and limits)

 and slope between the HOSY and portable devices with tights

 $\overline{x}$  = mean of four orientations; SD = standard deviation; LoA = limits of agreement; *B* = unstandardized beta coefficient of regression slope; CI = confidence interval. Mean [95% CI] HOSY pressure = 13.1 [12.6, 13.6] mmHg.