APPROPRIATENESS OF PLANTAR PRESSURE MEASUREMENT DEVICES IN A RESEARCH CONTEXT: A COMPARATIVE TECHNICAL ASSESSMENT.

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INTRODUCTION

The growing use of plantar pressure measurement devices (PMDs) both as a scientific research tool in biomechanics and as a diagnostic tool in clinics urgently calls for a rigorous scientific study on the quality and reliability of the existing systems available on the market. In 2006 ISS approved a 2-years scientific project aimed at setting up, validating and using dedicated testing methods and instruments for PMD technical assessment. Official letters were sent to Companies to invite them to take part to the study with their best product on the market. The testing phase closed on December 2008. Data processing is currently in its final step. Preliminary results are here reported which are referred to 5 most frequently used PMDs in biomechanic research.

METHODS

Testing devices and protocols.

A. A custom pneumatic bladder-based pressure tester was used to uniformly apply pressure over the entire PMD sensor matrix (accuracy ±1kPa). 50kPa step pressure was applied from 0 to 850kPa and down to 0, each step lasting 5s.

B. A dedicated pneumatic testing device with an on-off valve, a proportional valve, force and pressure controls (relative error <1%) was used to apply pressure in the range 0-600kPa under static and dynamic conditions over a small squared area (7.03cm^2). For each PMD, the following tests were performed over 5 randomly selected areas: 1) 100kPa steps of static pressure applied through the on-off valve from 0 to 600kPa and down to 0, each step lasting 5s, the area being completely offloaded after each step; 2) sinusoidal pressure cycles (0-500kPa; 0.75Hz; at least 10 cycles) applied through the proportional valve; 3) constant pressure ((350kPa; 60s) to investigate creep.

C. A special tool was used with test device B to apply a known vertical force through 3 round supports (7.07cm^2) of a graduated round table, to assess accuracy and precision of COP estimation. For each area, measurements were performed (load 500N) under 6 different angular positions (angular step 20°). Correctness of table position was assured by an ad hoc positioning system (angular resolution 5°).

Each PMD, considered as a whole with all its hardware and software components, was tested under its best working conditions by the same operator.

RESULTS AND DISCUSSION

Companies delivering low-cost PMDs did not even respond to the call. As for the others: RSSCAN and MEDILOGIC (resistive PMD) did not respond; IMAGO and TEKSCAN (resistive PMD) refused to participate; NOVEL and AM CUBE (capacitive PMD) participated. PMDs from RSSCAN, MEDILOGIC and TEKSCAN were taken from the market, 5 PMDs were tested in all.

Data processing is still in progress, but some evidences already emerged which are here briefly reported: 1) capacitive PMDs delivered better results than resistive PMDs as for accuracy of absolute pressure (Fig. 1), uniformity over the entire sensitive area, hysteresis. Worth to be noted, they did not ask for user calibration. NOVEL PMD showed better results than AM CUBE PMD; 2) as for resistive PMDs, TEKSCAN showed quite a good performance but asked for a complex user calibration, which could be hardly done in a clinical environment; 3) accuracy and repeatability of COP estimation was quite good for all PMDs but for RSSCAN (Table 1).

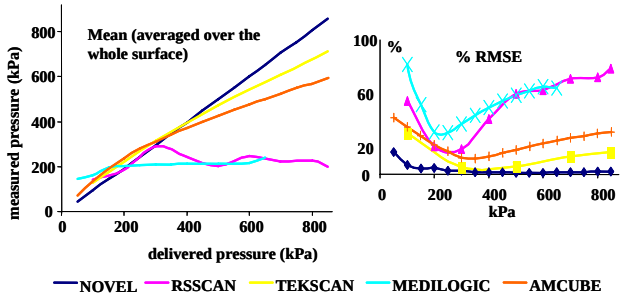

Figure 1: Mean value and % RMSE of step static pressure measured over the whole PDM surface (range 0-850kPa).

CONCLUSIONS

The ISS testing system proved to be appropriate to perform rigorous testing about accuracy and reliability of PMDs claimed as valuable instruments for biomechanical research. Testing procedures should be widely implemented since they are essential to minimize the onset of two major risks: on one hand, the prevention of using pressure measurements as meaningful quantitative information in biomechanical research; on the other hand, even worse, the risk of wrong diagnosis in clinics.

Table 1: Accuracy and precision of COP estimation for one randomly selected subarea of each PDM.

	NOVEL	RSSCAN	TEKSCAN	MEDILOGIC	AM CUBE
Resolution (sens/cm^2)	4	2.67	1.4	1.78	1.7
Accuracy (RMSE, cm)	x: 0.02; y: 0.07	not available	x: 0.19; y: 0.13	x: 0.51; y: 0.69	x: 0.30; y: 0.44
Precision (RMSE, cm)	x: 0.02; y: 0.04	not available	x: 0.07; y: 0.04	x: 0.13; y: 0.21	x: 0.29; y: 0.15