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COMPARISON OF DETECTED VALUES FOOTSCAN – KISTLER

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SUMMARY

Commercially available devices objectifying the amount of pressure under the foot are often different in accuracy and reliability of results. The aim of this pilot study was to compare output values of plantar pressure within one step generated by the system Kistler and Footscan. Software synchronization of both devices was performed and it was found from the subsequent evaluation that the values of forces obtained from the device Footscan are lower than these obtained from the Kistler system. This linear correlation may be only used in the evaluation phase of the maximum loaded foot (peak area); in the phase of lightening foot from the ground the system Footscan is burdened with a significant error of measurement, probably due to nonlinearity in the mechanical properties of the surface of the measuring plate.

Key words: Footscan, Kistler, measurement synchronisation, comparison

INTRODUCTION

Currently methods are often used in clinical and research practice objectifying the amount of pressure under the foot sole. There are many commercially available systems which differ in accuracy and reliability of results from each other. Only a few previous studies have examined the comparison of technical parameters of selected devices. In this work we focused on a device Footscan (RSscan) compared to the device Kistler. It is used in practice as methodologically precise equipment which is often taken as a standard to compare with other methods (Hurkmans et al., 2003). Similar studies have been done by Oosterlinck et al. who compared the outputs from the device Footscan and Kistler by synchronizing the measurements during the walk and trot of the horses. The most significant difference was when measuring peak vertical forces – the Footscan showed lower and delayed values of maximal force compared to the Kistler device (Oosterlinck et al., 2009). Similarly designed experiment was done to compare five methods of plantar pressure measurements, however, after agreement with the manufacturer of Footscan system it was carried out without data from this device, and in the future a deeper study of this problem should be done (Giacomozzi, 2010).

PURPOSE

The practice shows instability and low reliability in values obtained on measurements by the Footscan device, and so the experiment was designed to verify the output values coming from it based on comparison to the Kistler tensometric platform.

METHODS

Measuring device
Footscan

To detect the interaction dynamics of foot in contact with the ground a modular measurement system Footscan ® by RSscan International (RSscan International company Olen, Belgium) was used. The system consists of a sensor desk, connecting interface and the analysing software. Footscan ® software allows to evaluate diagnostically the dynamic "footprint", the size of the contact area (cm^2), timing of the contact of foot regions (ms), the loading parameters (N, N/cm^2), relative position of parts of regions, the width and length of feet. In addition, the software offers the ability to export all data in ASCII format (curves of loading as a function of time) (User Manual Footscan® 7, 2008).

Technical parameters:
Board Size: 2 × 0.5 m
Removable range: 0.27 N/cm^2 – 127 N/cm^2
(2.7 kPa – 1270 kPa)
Max. 3D box frame rate: 500 Hz
Number of modules: 4
Number of rows of sensors in one module: 64 × 64
Number of sensors in one module: 4096
Sensor Size: 5 × 5 mm
Resolution: 4 senzory/cm^2
Max. value of one pixel: 255 AD

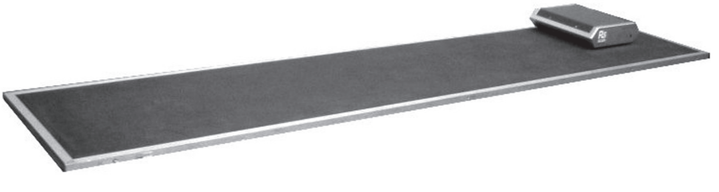

Figure 1. Footscan measuring plate

Kistler

Tensometric desk by Kistler company (Kistler Instrumente AG, Winterthur, Switzerland) was used to obtain a real value of the stress forces during the stance phase of gait. This device provides data of the reaction force vectors between foot and ground, which are mediated by piezoelectric power sensors (Kistler company®, 2008).

Technical parameters:
Board size: 60 × 40 × 10 cm
Weight: 40 kg
Measuring range: 20 kN
Time resolution: 1000 Hz

Figure 2. Tensometric plate Kistler

Software synchronization was used for systems Footscan and Kistler to obtain real values of pressure under all regions of the foot. The power plate served in this case as an accurate measuring device to obtain the real load of the foot during the stance phase of gait in time, and the Footscan platform placed on it was used to capture the relative distribution of pressure under foot regions. Weight parameters were included in the devices calibration system and set to zero.

Software synchronization of both curves showing the values of plantar pressure during one stance phase of gait has been carried out. According to the chosen sampling frequency of 100 Hz corresponding values of forces were exported from both used technologies and their sequences were compared. For purposes of this pilot study we used this method to measure one step only.

RESULTS

The first way to carry out the "calibration" was to make the ratio of obtained values of forces from the systems Kistler and Footscan. From these values it was possible to calculate a "calibration constant". However, this ratio differs in some intervals of foot interaction; it would be useful to apply a more complicated mathematical operation to obtain a „calibration function" that could be related to all values of the curve. We calculated mean ratios of the values in the two areas of the highest load of step (peaks). From these we obtained an

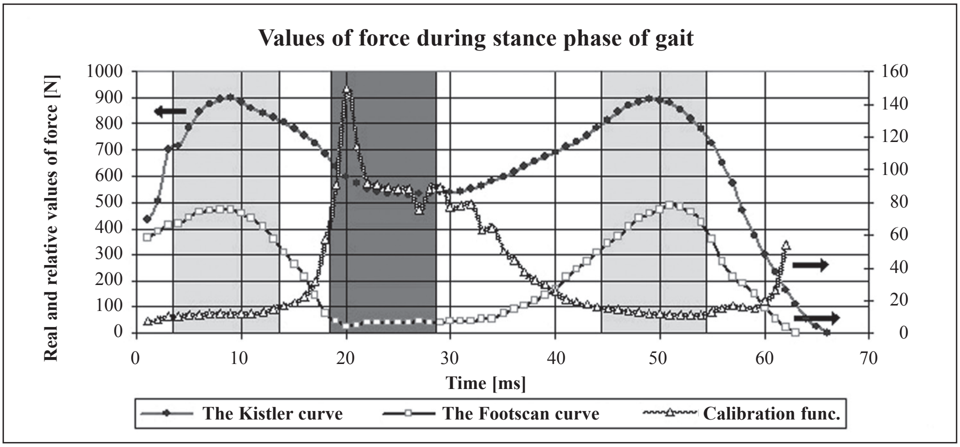

Figure 3. Curves of foot loading during stance phase of gait obtained by Kistler and Footscan device. The peak zones are marked by light colour (from this area the most accurate "calibration factor" was calculated), the area of the largest error of the Footscan curve is marked by dark colour. The arrows indicate the corresponding scale.

accurate "calibration factor". For comparison the same ratio was calculated in the greatest inaccuracies of the function to determine how big error is Footscan in this moment burdened with.

An analysis of the calibration function shows that the properties of Footscan are strongly nonlinear in the lightening phase of the step. In contrast, in the peak areas it is obvious that the properties of measuring device are relatively stable and its function in this region can be considered within certain limits, to be constant. Each of these areas contains 10 values, for which we performed the analysis and subsequent comparison.

Table 1. Calculating of the calibration constant using the calibration function.
We can summarize that the measuring system Footscan was in this one step outside the peak areas burdened with a significant error, especially.

Calibration constant for peak 1	12.04
Calibration constant for peak 2	12.41
Calibration constant for the area of the largest mistake	96.75
Calibration constant for the whole contact between foot and ground	37.13

The second way we can get more accurate results is the calculation through the impulse of force acquired from the two devices. From the values of forces obtained from Footscan and Kistler plates we calculated the integrals and obtained their ratio which can be regarded as "calibration coefficient". This factor can be applied to the value of impulse of force under each foot region to obtain a real value of load under this region. The obtained values for the examined step are as follows:

Table 2. Calculating of the calibration coefficient using the force impulse of both curves

Impulse of force [Ns]	Peak 1 area	Peak 2 area	Area of the largest mistake	Whole step
Kistler	84.37	85.40	55.58	417.77
Footscan	7.04	6.95	0.59	26.32
Calibrating coefficient	11.98	12.29	94.21	15.87

This method of "calibration" seems to be more usable for the whole process of the step because in this case the average error for the entire phase of foot contact with the ground calculated from ratios of integrals of both curves was only 25%. Subsequent conversion of values of force obtained by Footscan using this coefficient for the whole step would then look like this:

Table 3. The values of load under particular regions of the foot from the Footscan system and their conversion to the absolute values of load using calibration coefficient.
T1–5 – toes area, M1–5 – metatarsal area, MF – midfoot, HM – medial heel, HL – later

Zone	Relative force	Absolute force [N]
T1	15.00	238.09
T2-5	15.00	238.09
M1	1.90	30.16
M2	0.00	0
M3	0.00	0
M4	0.00	0
M5	3.40	53.97
MF	0.00	0
HM	13.50	214.28
HL	11.60	184.12

DISCUSSION

In this study a "calibration constant" was calculated that should help us to get more accurate results, when making product with a relative value of force from the Footscan device. To specify this statement it is necessary to do more measurements which could clarify whether the degree of relativity of the measured values is repeatable. If so, the outputs would be sufficient for comparative studies. This procedure, however, can only be reliably applied for the two load peak areas in the foot contact with ground (in the other case for example when unloading foot from the ground is the output from the system Footscan significantly nonlinear. This inaccuracy is probably caused by mechanical properties of the measuring board, such as the softness of the surface and mechanical deformation during loading. Synchronization of measurements presented in this study was burdened with some error because of the shift. The technical equipment does not allow measuring of both devices simultaneously, so we did a software synchronization of both curves of the foot loading during the step. We are aware that the latest Footscan measuring devices are already commercially available including the synchronization cables, our study, however, operates with equipment we had available, and is generally applicable to any device. Other problematic area in evaluating the outputs from the system Footscan is that, instead of records of pressure on the real sole, there are only the records of pressure on the pattern of the sole, which is defined in the software, depending on the determination of its size. It should also be taken in mind that only one step has been evaluated, and so the measurement uncertainty of both instruments is not known. Therefore it is necessary to design larger studies, preferably using hardware synchronization of measurements.

CONCLUSION

The carried out measurment illustrates that the Footscan system does not prove to be fully satisfactory for determining the real contact forces acting on the sole. This claim does not reduce the importance of this system for clinical applications for which it is designed and even well equipped with an appropriate software. By following the described procedure, once it is verified properly, it may be possible to eliminate the measurment error of the Footscan system, so that the recorded data may be trusted even it their absolute values. After some necessary adjustments, naturally, the proposed "calibration" procedure may further be generally applicable to any kind of devices.

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POROVNÁNÍ NAMĚŘENÝCH HODNOT FOOTSCAN A KISTLER

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SOUHRN

Komerčně dostupná zařízení objektivizující velikost tlaku pod ploskou nohy se často liší přesností a spolehlivostí výsledků. Cílem této pilotní studie bylo porovnání výstupních hodnot tlaku během jednoho kroku získaných ze systému Footscan a Kistler. Byla provedena softwarová synchronizace výstupních hodnot z obou zařízení a dle následného vyhodnocení bylo zjištěno, že hodnoty síly působící na podložku získané z přístroje Footscan jsou nižší než ze systému Kistler. Tato lineární souvztažnost lze však použít pouze v hodnocení fází maximálního zatížení nohy (oblast peaků), ve fázi odlehčování nohy od podložky je systém Footscan zatížen značnou chybou měření, pravděpodobně v důsledku nelineárnosti mechanických vlastností povrchu měřicí desky.

Klíčová slova: Footscan, Kistler, porovnání výstupů, synchronizace měření

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