A verification of the accuracy of Smart Sock System for monitoring of temporal parameters of locomotion

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New pressure sensors that can be knitted in directly in the garment or hosiery items were developed. Based on this technology, Smart Sock System was created for sport and medical applications [1]. Each Smart Sock has five knitted sensors placed in the accord. The conductive lines are knitted during manufacturing of the socks, using yarn with lower resistance then one used for the sensors. Conductive lines ended with the metal buttons snap fasteners, mounted on the upper part of socks. Data are transmitted through two Bluetooth devices.

The aim of present study was to verify and compare temporal characteristics of Smart Sock System with two other methods widely used for locomotion parameters monitoring.

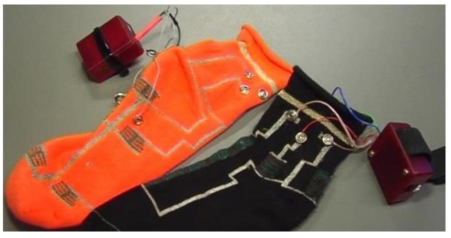

Figure 1. Smart Sock System

One method for comparison was force platforms (BTS P-6000, Italy), sampling at 1000 Hz. The sensitive area of force plates was 60 x 40 cm, minimum height - 5.7 cm. Runners performed one successful running step over the force plates at one time. Other method was optical system (OptoJump Next, Microgate, Italy).

Three types of locomotion were analysed: walking (only with the optical system, Fig.2.A), race walking (Fig.2.B) and running (only with the optical system, Fig.2.C).

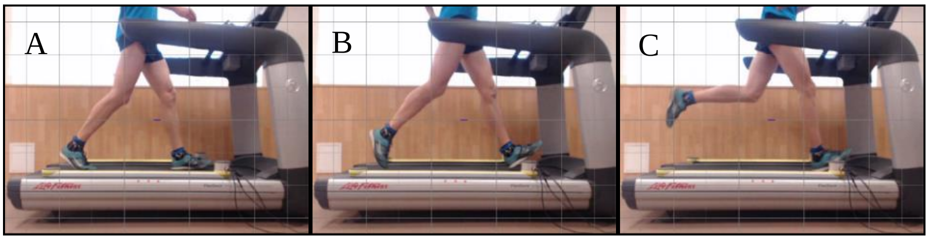

Figure 2. Three different types of locomotion. A – walking, B – race walking, C – running.

Ground contact time was defined as the time from when the foot contacts the ground to when the foot toes off the ground (measured with force platforms). Step time was defined as the time from when one foot contacts the ground to when the other foot contacts the ground (measured with optical system).

Participants performed repeated steps over the force plates and continuous activity on motorised treadmill while measuring with the optical system. Both systems have previously been shown as able to determine these variables accurately.

The Bland-Altman plot was used to determine agreement between methods. The mean difference between step times was 0.0027s in walking (n=167, Fig.3.A), -0.0024s in race walking (n=252, Fig.3.B) and -0.0013s in running (n=275, Fig.3.C). Graphical representation of difference between Smart Socks and OptoJump is shown in Figure 3.

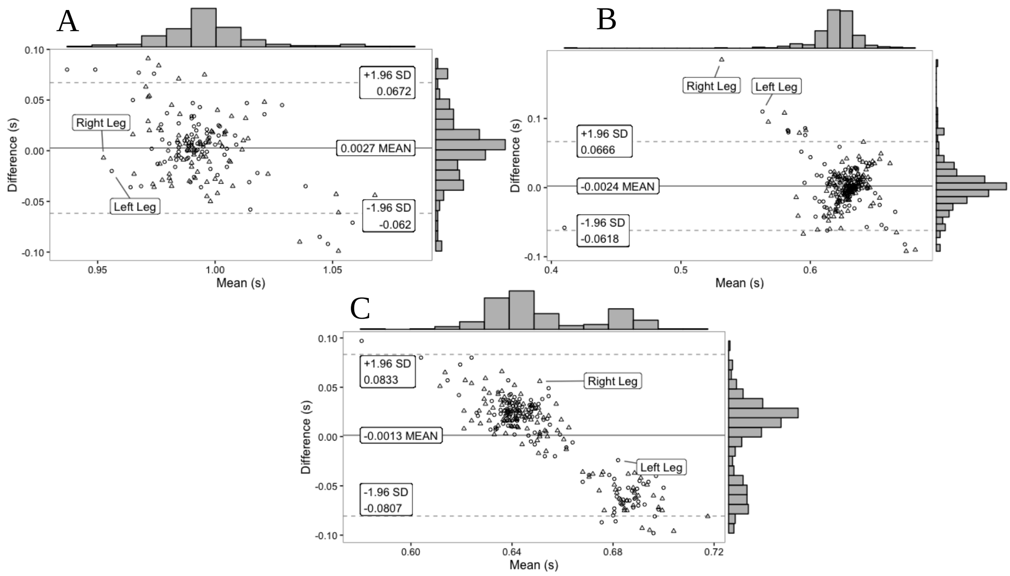

Figure 3. The level of agreement plots (Bland-Altman) showing 95% limits of agreement (dashed lines) between methods. Solid black line represents the mean bias between methods. A – walking, B – race walking, C – running.

Coefficient of variation (CV) during race walking was higher within values measured by Smart socks (24%) compared to Optojump – 12%. While running, CV was higher within values measured by Smart socks (17%), compared to Optojump – 1%. It could be partly explained by artefacts. As the mean difference was close to zero, it shows that none of two methods measured significantly ($p>0.05$) higher or lower step time values in any of three types of locomotion. We conclude that methods showed results of practically equal step times during three types of locomotion. And it could be a practical tool using for sport purposes.

Mean difference between ground contact times in race walking (n=89) was -0.017s. The difference was statistically significant ($p<0.01$). The mean ground contact times were 0.281s (Smart Socks) and 0.298s measured with force plates. The time of mean difference makes 5-6% of the contact phase time. We conclude that this difference is acceptable if using for practical purposes. More data needed for deeper analysis.

References

[1] Oks A, Katashev A, Zadinans M, Rancans M, Litvaks J. *Development of Smart Sock System for Gate Analysis and Foot Pressure Control.* MEDICON 2016 IFMBE Proceedings **57**. Springer International Publishing Switzerland 2016.

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