MINIMAXX PLAYER LOAD AS AN INDEX OF THE CENTER OF MASS DISPLACEMENT? A VALIDATION STUDY

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The purpose of this study was to assess the concurrent validity of the player load computed by the MinimaxX accelerometers by comparing it to the player load computed by a gold standard method based on in series force platforms. Fourteen participants were instrumented with two accelerometers (MinimaxX S4, Catapult, Australia) during specific team sport displacements performed on the force plates. Pearson correlation coefficients were ranged from 0.74 to 0.93 while the coefficients of variation varied from 6.9 to 16.4%. The standard error of the estimate was small (<0.6) or moderate (0.6-1.2). The validity of the accelerometers is good or very good for the different tested exercises. These results suggest the player load parameter computed with MinimaxX accelerometers seems able to characterize the physical demands in team sports.

KEY WORDS: Concurrent validity, Accelerometers, In series Force plates, Team sport

INTRODUCTION: Microtechnology devices provide important information about the physical and physiological demands during sport practice. From a mechanical point of view, the recent literature in sport science reveals that the player load (PL) is one the most used parameters for quantifying the physical activity both in indoor and outdoor team sports like basketball (Montgomery et al., 2010), rugby (Jones et al. 2015), Australian football (Boyd et al, 2011) or soccer (Scott et al. 2013). Measured by wearable triaxial accelerometers, PL combines the accelerations produced in the 3 planes of body movement. The recent studies quantifying PL by means of MinimaxX sensors (Catapult, Australia) have shown a high reliability in both inter- and intra-device (Boyd et al. 2011). Furthermore, on the basis of a construct validity approach, Montgomery et al. (2010) evidenced that this new indicator is able to detect change in physical demands between different basketball drills. They justify such a statistical approach by the fact that it relates to basketball attributes which cannot easily be measured (e.g. nonquantifiable actions such as multisegmental movements). Consequently, they attempted to determine if there were substantial differences in outputs derived from the accelerometer data across several trials of the same movement patterns.
To our best knowledge, no concurrent validity approach has been undertaken to estimate whether the PL computed classically at the upper back level by the MinimaxX reflects the PL concomitantly measured at the center of mass (COM). In the present study, we had the unique opportunity to measure simultaneously the 3 components of the accelerations both by means of accelerometers and in series force platforms.
Thus, the aim of this study was to assess the concurrent validity of the player load measured by the MinimaxX accelerometers by comparing it to the player load measured by force plates. Additionnally, we tried to identify whether there was an effect of i) the sensor location [upper back (UB) vs lower back(LB)] and ii) the intensity of the movement on this validity?

METHODS: Fourteen participants (age: 27.4 ± 7.1 years; height: 178 ± 4 cm; body mass: 75.1 ± 5.4 kg) were instrumented with two accelerometers (MinimaxX S4, Catapult, Australia; 100 Hz). The first sensor was located in the center of the upper back with a standard harness, approximately 5 cm lower than the base of the neck. The second sensor was fixed by bi-adhesive support on the middle of the lower back, over the horizontal axis determined by the posterior superior iliac spines. The movements were realized over 6 individual force plates connected in series (KI 9067; Kistler, Switzerland; piezoelectric sensors; 1.20 x 0.6 m; 1000 Hz). The second force plate is turned by 90 degrees such that the length of the force plate area was 6.6 m. This system allows the recording of vertical, anteroposterior and lateral components of the ground reaction force. Player load was calculated as follow:

$$\text{Player load} = \sqrt{\frac{(a_{y1}-a_{y-1})^2+(a_{x1}-a_{x-1})^2+(a_{z1}-a_{z-1})^2}{100}}$$

where a_y is the forward acceleration, a_y is the sideways acceleration and a_z is the forward acceleration.
After a standardized warm-up, the participants were asked to perform randomly 3 types of movement which corresponded to different team sport displacements. Every type of movement was performed at low (slow run) and high (maximal) intensity. These movements were i) general displacements that consisted of coming and going along the force plate area in forward, lateral, and backward runs as well as a coming and going by walking, ii) a running start and iii) a simulated 1x1, that consisted in a 2 m acceleration followed by double step on the perpendicular force plate and a sudden direction change. Force platforms and accelerometers signals were synchronized by a cross-correlation analysis (see example on fig. 1).

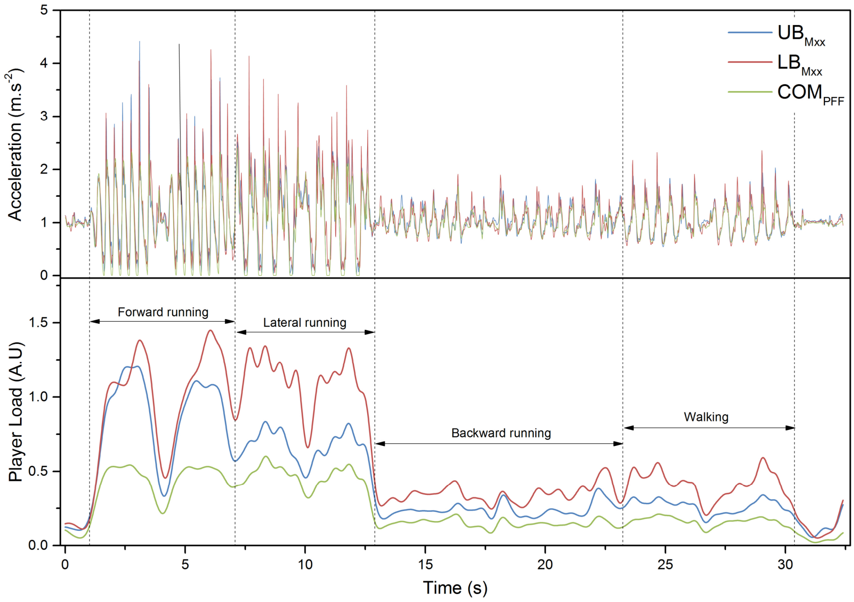

Figure 1: Typical example of the acceleration (in m.s^{-2}) and player load (in A.U) signals against time (in s) measured with the MinimaxX accelerometers located in the upper back (UB_{MXX}) and the lower back (LB_{MXX}) and with the force plate system (COM_{PFF}) during the general displacements.

To determine the concurrent validity, the parameters were log-transformed to reduce bias due to nonuniformity of error (Hopkins, 2000). Then, linear regressions were performed between PL of accelerometers and force plate, and we calculated the Pearson correlation coefficient (r), the coefficient of variation (CV) and the standard error of estimate (SEE is described as trivial if <0.2; small between 0.2 and 0.6; moderate between 0.6 and 1.2; large between 1.2 and 2.0; and very large if >2). The level of concordance between the MinimaxX and the force plates measurements was estimated by Bland and Altman (1986) plots with 95% limit of agreement (LoA; mean difference ±1.96 SD).

RESULTS: The validity parameters are presented in table 1. For UB_{MXX}, Pearson correlation coefficients were ranged from 0.82 to 0.87 at low and 0.74 to 0.90 at high intensities. CV were ranged from 9.2 to 12.9% at low and 6.9 to 16.4% at high intensities. SEE were considered as small (<0.6) except for the running start at high intensity for which SEE is moderate. For LB_{MXX}, Pearson correlation coefficients were ranged from 0.77 to 0.84 at low and 0.74 to 0.93 at high intensities. CV were ranged from 11 to 14.5% at low and 8.5 to 11.0% at high intensities. Whatever the tested intensity, SEE are considered as moderate (0.2-0.6) for the general displacements and small (<0.6) for the simulated 1x1 exercises. The

SEE for the running start is moderate (0.2-0.6) at low intensity and small (<0.6) at high intensity. The Bland and Altman plots are presented on figure 2. Despite systematic positive bias (ranged from 35 to 95% of the mean for UB_{MXX} and from 78.7 to 113.8% of the mean for LB_{MXX}) a noticeable accordance between the accelerometers and the force platform measures was observed for each intensity and each accelerometer location.

Table 1

Concurrent validity of the player load measured by the upper back (UB_{MXX}) and lower back (LB_{MXX}) MinimaxX accelerometer with the reference method. Pearson correlation coefficient (Pearson r), intra-class correlation (ICC), coefficient of variation (CV) and standardized error of estimates (SEE) calculated for the 3 tested displacements, at low (low int.) or high (high int.) intensity.

		COM_{PFF}/UB_{MXX}		COM_{PFF}/LB_{MXX}	
		Low Int.	High Int.	Low Int.	High Int.
General displacements					
	Pearson r	0.85	0.86	0.79	0.79
	CV	9.2	6.9	11.0	8.5
	SEE	0.54	0.53	0.64	0.64
Running start					
	Pearson r	0.82	0.74	0.77	0.89
	CV	12.9	16.4	14.5	11.0
	SEE	0.59	0.70	0.66	0.48
Simulated 1x1					
	Pearson r	0.87	0.90	0.84	0.93
	CV	11.0	12.3	11.9	10.3
	SEE	0.52	0.46	0.56	0.39

DISCUSSION: This study is the first one that tests the concurrent validity between the player load parameter measured with accelerometry and force platforms. The main results showed that the validity of the accelerometer located both at the upper back and the lower back is good or very good (CV: 6.9-16.4). Whatever the type of movement, the graphic analyses demonstrate that experimental values were within the limits of agreement (Fig. 2). The effect of both the intensity and the location is very low or trivial. These results suggest, as previously evidenced (Montgomery et al., 2010; Boyd et al, 2011), that the MinimaxX seems able to characterize the physical demands in team sport. Nevertheless, we observed that the bias of PL measures for the accelerometers were very high (43.3-113.8% of the mean). This is more pronounced in the lower than the upper back location. Due to the mode of PL calculation (see methods section), this parameter is extremely sensitive to vibrations. Albeit speculative, the vibrations of the accelerometers should explain these high bias values. It is noticeable that this had no or low influence on the global accordance between the force platform and MinimaxX data.

CONCLUSION: The validity of the accelerometers is good or very good for the different tested exercises. These results suggest the player load parameter measured with the micro sensors MinimaxX seems able to characterize the physical demands in team sport.

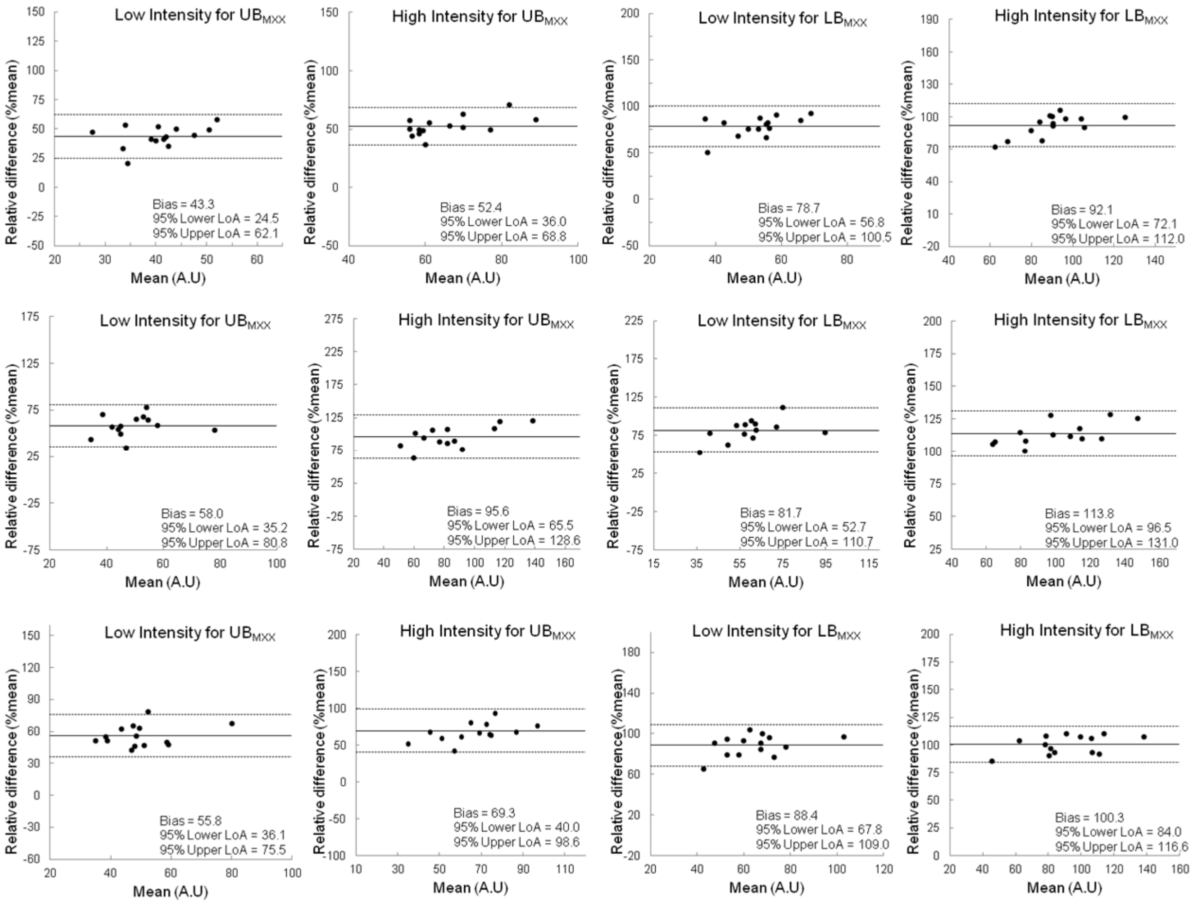

Figure 2: Bland-Altman plots of player load measured both by the upper back (UB_{MXX}) and lower back (LB_{MXX}) MinimaxX and by the reference method (force platforms). Bias (in % of the mean) and 95% lower and upper limits of agreement (LoA) are indicated for each plot.

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Acknowledgement
This study was supported by the Ministry of Sports, Youth, Popular Education and Community Life and the French Institute of Sport (INSEP). The authors would like to thank the French Handball Federation for its collaboration in this project.