ASSESSMENT OF ANALYSING BLOCK START PERFORMANCE WITHOUT ARM GROUND REACTION FORCES

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The purpose of this study was to assess the analysing reaction time (RT) and normalized power when calculated using two different methods: a method using ground reaction forces (GRFs) of only the legs (legs F-based method) and a method using GRFs of arms and legs (whole F-based method). In total, 127 block start motions from fourteen male sprinters were analysed from all participants. The RT of the legs F-based method was not similar to that of the whole F-based method: the mean difference was 7.4 ms and the 95% CI was –45.1–59.8 ms. In contrast, the normalized power of the legs F-based method was similar to that of the whole F-based method. This information will help reconsider the golden standard methods currently used to analyse RT and encourage the use of analysis methods to analyse the performance in block starts.

KEY WORDS: reaction time, block power, starting block, sprinters.

INTRODUCTION: An accurate calculation is required to assess longitudinal changes in block performance within athletes and to identify important differences of these changes between athletes. Nonetheless, there remain several important methodological problems when calculating sprint start performance parameters: First, the most common signal type used are ground reaction force (GRF) signals; however, force sensor-based methods in many previous studies did not consider the effect of force production capacities of the sprinters' arms on the reaction time (RT) calculation (Komi et al., 2009). From these observations, the purpose of this study was to assess the analysing RT (the duration from response signal onset to the first discernible change in focal force-generation activity) and the average horizontal external power of the centre of mass of the whole body (COM) normalized to body characteristics (hereafter, normalized power; Bezodis et al., 2010) between two different methods: a method using GRFs of legs captured by FPs (legs F-based method) and a method using GRFs of arms and legs (whole F-based method). It was hypothesized that block start performance by legs F-based method would be different from that by whole F-based method.

METHODS: Fourteen male sprinters participated in this study (mean ± standard deviation [SD] 11.00 ± 0.44 s in 100-m personal best). During the experimental trial, kinetic and kinematic data were simultaneously collected at a frequency of 1000 Hz and 250 Hz, respectively. These sampling frequencies were often used in many previous studies. GRFs of hands and feet were separately sampled from four force plates (0.60 m × 0.40 m; TF-4060-B; Tech-Gihan Inc., Kyoto, Japan) arranged in two rows and two columns.
In total, 127 block start motions were analysed from all participants. When filtering the raw data of GRFs of arms and legs separately, a recursive fourth-order zero-lag Butterworth filter was applied to the force signals with optimal cut-off frequencies determined using residual analysis (Winter, 2009).
In legs F-based method, the RT generated by the sum of the two GRFs of the lower limbs was calculated using a threshold of 5 SD above the average magnitude of the GRF in the baseline zone (from 40 ms before gunfire to gunfire). The normalized power was calculated (Bezodis et al., 2010) using the legs GRF only. In whole F-based method, the same data analysis was performed as in the legs F-based method but this time using the sum of the four GRFs of the legs and arms for calculating the RT and normalized power.

To quantify the agreement between the methods, Bland–Altman plots were created for each method pair for RT and normalized power. The bias was determined as the mean difference (fixed bias) and the 95% CI calculated as the mean difference ± 1.96 x SD of the difference (Bland and Altman, 1986).

RESULTS: As a typical example shown in Figure 1, when using optimal cut-off frequencies in low-pass filtering, few differences of the horizontal COM acceleration were observed between the raw data and filtered data in the legs and whole F-based methods. The RT and normalized power are shown in Table 1.

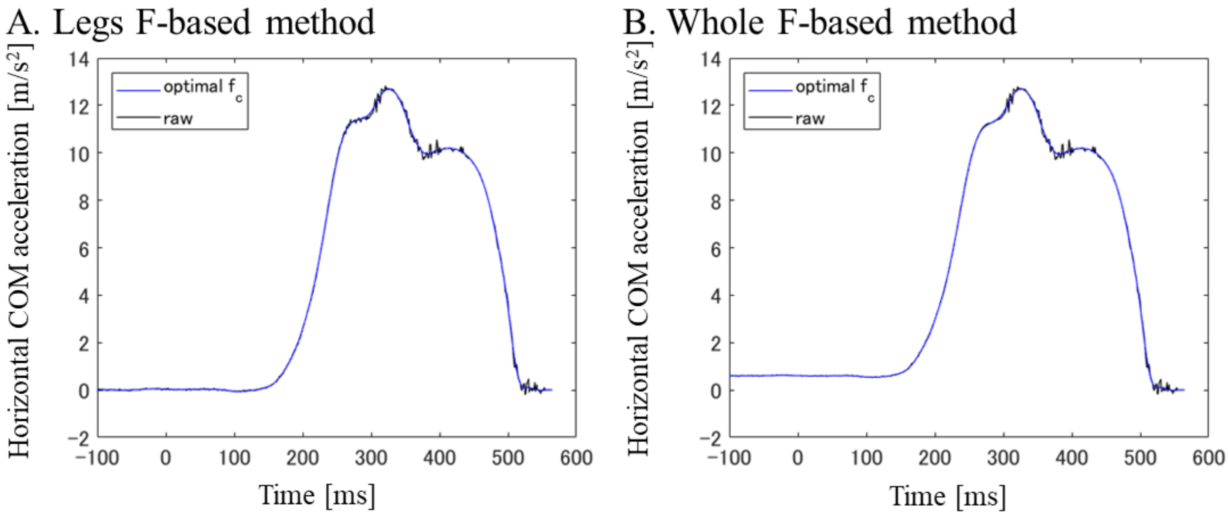

Figure 1: Typical example of horizontal COM acceleration in the legs (panel A) and whole (panel B) F-based methods

Table 1: RT and normalized power in two different detecting methods

	RT [ms]	Normalized power
Legs F-based	126.4 ± 24.3	0.522 ± 0.081
Whole F-based	119.1 ± 29.3	0.513 ± 0.078

Figure 2 shows Bland–Altman plots on block performance between legs and whole F-based methods. The RT of the legs F-based method was not similar to that of the whole F-based method: the mean difference was 7.4 ms and the 95% CI was –45.1–59.8 ms. In contrast, the normalized power of the legs F-based method was similar to that of the whole F-based method: mean difference was 0.009 and the 95% CI was –0.050–0.067.

DISCUSSION: Regarding the legs F-based method, the proportional bias was small; however, fixed bias of RT was clearly over 3.0%. Joints closer to the central nerve move earlier rather than those in the lower limbs (Komi et al., 2009) because of shorter nerve distances. Therefore, the delayed RT of the legs F-based method may be due to the fact that first changes in GRFs of arms could not be sensitively captured by GRF measurements in the legs only. In addition, the 95% CI for the difference of RT between two methods was –38.0–50.4%. As Figure 2-A shows, a few differences of RT between legs and whole F-based methods were less than –70 ms. For the legs and whole F-based methods, the RTs were determined by using the 5 SD of force signals in the baseline zone. At the set position, the sprinters' arms are required to continue to generate greater magnitude of GRFs (Otsuka et al., 2014) using smaller muscle volumes (Tanaka and Kanehisa, 2014), compared to those in legs. This might lead to different high frequency components among arms and legs GRF in the baseline zone; thereby, the thresholds for detecting onset instant and RTs were different between legs and whole F-based methods. In contrast, the normalized power by the legs F-based method was more valid because the fixed bias was less than |3.0|%, the proportional bias was less than |0.300|, and the 95% CI (–9.7–13.1%) was within a narrow range. This may be because that the horizontal braking impulse by arms is negligibly smaller than propulsive force applied by the legs (Gutiérrez-Dávila et al., 2006; Otsuka et al., 2014). Thus, our hypothesis was accepted in RT but was rejected for normalized power.

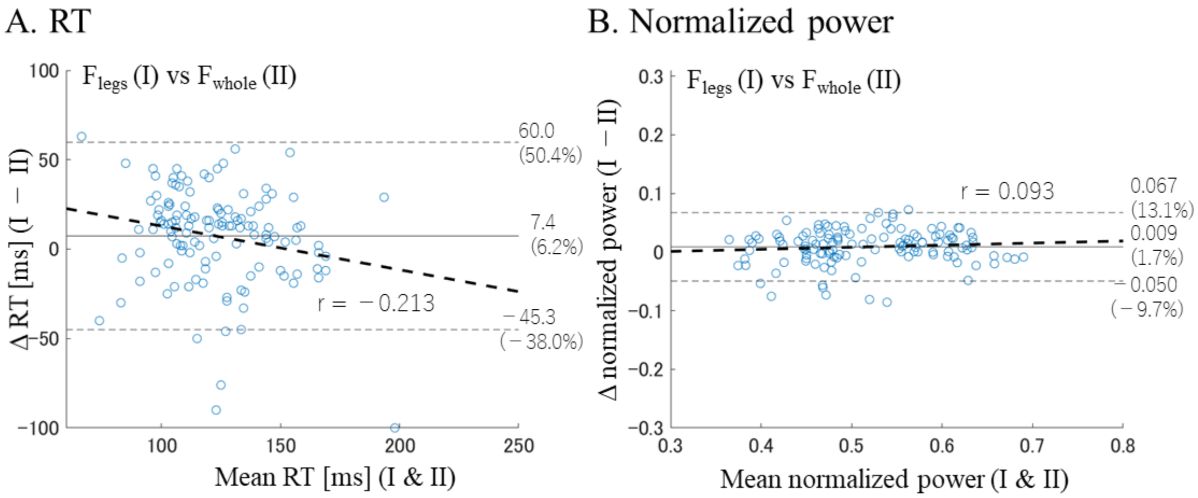

Figure 2: Bland–Altman plots for comparison of RT (panel A) and normalized power (panel B) between the legs (F_{legs}) and whole (F_{whole}) F-based methods. Horizontal gray solid line shows the mean difference between two methods, horizontal gray dot line shows the 95% CI of the difference between two methods, and black dot line shows the linear regression line between mean value and difference.

CONCLUSION: Because a force sensor-based method without considering arm GRF, which is very often used, overestimates the calculation of RT, the appropriate methods should be carefully considered in competitive races during false start detection. In contrast, the normalized power in the action phase can be calculated using a force sensor-method without considering arm GRFs. This information will help reconsider the golden standard methods currently used to analyse RT and encourage the use of often used methods to analyse the performance in block starts.

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