

SHORT COMMUNICATION

Foot speed, foot-strike and footwear: linking gait mechanics and running ground reaction forces

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ABSTRACT

Running performance, energy requirements and musculoskeletal stresses are directly related to the action–reaction forces between the limb and the ground. For human runners, the force–time patterns from individual footfalls can vary considerably across speed, foot-strike and footwear conditions. Here, we used four human footfalls with distinctly different vertical force–time waveform patterns to evaluate whether a basic mechanical model might explain all of them. Our model partitions the body's total mass ($1.0M_b$) into two invariant mass fractions (lower limb=0.08, remaining body mass=0.92) and allows the instantaneous collisional velocities of the former to vary. The best fits achieved (R^2 range=0.95–0.98, mean=0.97±0.01) indicate that the model is capable of accounting for nearly all of the variability observed in the four waveform types tested: barefoot jog, rear-foot strike run, fore-foot strike run and fore-foot strike sprint. We conclude that different running ground reaction force–time patterns may have the same mechanical basis.

KEY WORDS: Force-motion, Biomechanics, Running performance, Barefoot running

INTRODUCTION

The bodily motion of terrestrial animals that use bouncing gaits is determined by the action–reaction forces between the limbs and the ground. However, the predominant orientation of these forces during straight-path, level running and hopping is not in the horizontal direction of travel (Cavagna et al., 1977). Horizontal force requirements are minimized by an effective step-to-step maintenance of forward momentum once an animal is up to speed. Vertical force requirements, in contrast, can exceed body weight by a factor of two or more during periods of limb–ground contact (Weyand et al., 2000). Large vertical forces result from two factors: the need for stride-averaged vertical forces to equal the body's weight, and limb–ground contact periods that comprise only a fraction of the total stride time. Consequently, the vertically oriented ground reaction forces exceed horizontal forces by a factor of five or more, and lateral forces by greater margins.

The vertical force versus time waveforms of individual running and hopping footfalls can vary considerably in duration, amplitude and shape. This variation has been documented for a variety of species (Cavagna et al., 1977) and most comprehensively for humans (Bobbert et al., 1991; Munro et al., 1987). At present, several factors are known to introduce the shape variation that occurs predominantly in the initial portion of these force–time waveforms. These include: running speed (Bobbert et al., 1991;

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Kuitunen et al., 2002; Munro et al., 1987; Weyand et al., 2009; Weyand et al., 2010), the portion of the foot that initially contacts the running surface (Cavanagh, 1987; Chi and Schmitt, 2005; Dickinson et al., 1985; Ker et al., 1989; Lieberman et al., 2010; Nigg et al., 1987) and footwear (Liu and Nigg, 2000; Ly et al., 2010; Nigg et al., 1987; Nigg and Liu, 1999; Zadpoor and Nikooyan, 2010). Current understanding rests heavily on the two types of models most frequently used to interpret these waveforms: the spring-mass model and multi-mass models. Models of both types are well-founded and have undergone extensive evaluation. However, neither was formulated to explain these waveforms in full.

The most basic treatment of the vertical force–time waveforms is provided by the classic spring-mass model (Blickhan, 1989; McMahon and Cheng, 1990). The single-mass approach models running and hopping animals as a lumped point-mass mass bouncing on a massless leg spring. This single-mass model explains many aspects of running and hopping gaits with remarkable accuracy given its mechanical simplicity (Bullimore and Burn, 2007; Farley et al., 1993; Ferris and Farley, 1997; McMahon and Cheng, 1990). However, this classic model was formulated largely for broad evaluative purposes, not specific quantitative ones. Accordingly, the perfectly symmetrical force–time waveforms the model predicts (Bullimore and Burn, 2007; Robilliard and Wilson, 2005) cannot account for the non-symmetrical components that the force–time waveforms inevitably contain. These include, but are not limited to, heel-strike impacts at slow speeds and extremely rapid rising edges at faster ones (Kuitunen et al., 2002; Weyand et al., 2009; Weyand et al., 2010).

A second, more complex variety of multi-mass models developed from the two-mass ideas initially put forward by McMahon (McMahon et al., 1987) and Alexander (Alexander, 1988). These models have evolved in their complexity, largely by building upon Alexander's two-mass, stacked-spring model (Alexander, 1988; Alexander, 1990; Derrick et al., 2000; Ker et al., 1989). Contemporary versions include at least four masses and more than a dozen spring, mass and damping elements (Liu and Nigg, 2000; Ly et al., 2010; Nigg and Liu, 1999; Nikooyan and Zadpoor, 2011; Zadpoor and Nikooyan, 2010). In contrast to the single-mass models, a primary objective of the multi-mass models has been to provide detailed explanations of waveform variability, specifically the impact and rising-edge variability observed for human joggers (Nigg, 2010; Zadpoor and Nikooyan, 2010). However, the relatively specific objective of the multi-mass models has limited the breadth of their application. Evaluations typically ignore the descending edge of the waveforms and have been limited to jogging speeds. Accordingly, the ability of the now-elaborate, multi-mass models to explain either the falling edge of jogging waveforms or the entirety of the waveforms from intermediate and fast running speeds is not known.

Here, we seek to explain running ground reaction forces in full with an approach that is slightly more complex than the single-mass

models, but considerably simpler than current multi-mass models. For this purpose, we formulated a two-mass model that theorizes that running vertical force–time waveforms consist of two components, each corresponding to the motion of a discrete portion of the body's mass. A smaller component (m_1) corresponds to the impact of the lower limb with the running surface while a larger component (m_2) corresponds to the accelerations of the remainder of the body's mass (Fig. 1A). We hypothesize that our two-mass

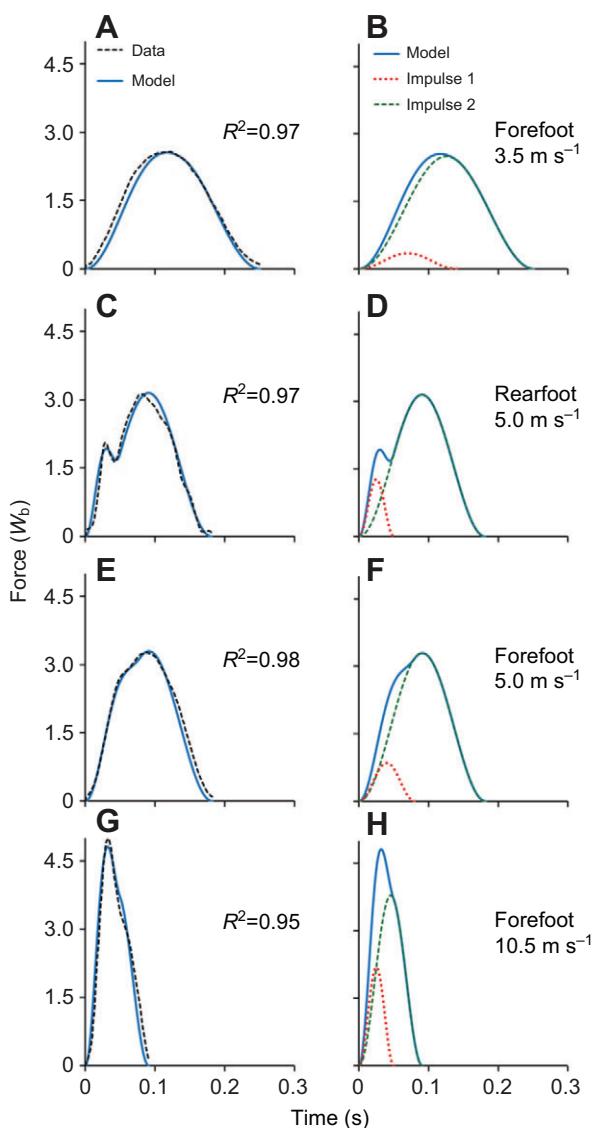


Fig. 1. Modeled versus actual vertical ground reaction force waveforms from four different running footfalls. (A,B) Barefoot, fore-foot strike at 3.5 m s^{-1} ; (C,D) shod, rear-foot strike at 5.0 m s^{-1} ; (E,F) shod, fore-foot strike at 5.0 m s^{-1} ; (G,H) shod, fore-foot strike at 10.5 m s^{-1} . A, C, E and G illustrate the two-mass model (solid blue line) compared with the digitized waveforms (dashed black line). B, D, F and H illustrate the contributions of the first impulse (J_1 , dotted red line) and second impulse (J_2 , dashed green line) to the total predicted by the model (solid blue line). Modeled versus digitized waveform R^2 values are provided in the figure; root mean square error values were 0.15, 0.16, 0.15 and $0.35W_b$ for waveforms 1–4, respectively. [Note: the model assumes that the force contributed by m_1 after impulse J_1 has ended is zero; original sources for waveforms 1–4 were: Lieberman et al. (Lieberman et al., 2010), their fig. 1c, step #1; Weyand et al. (Weyand et al., 2000), their fig. 1B, step #2; Weyand et al. (Weyand et al., 2010), their fig. 1A, step #1; Weyand et al. (Weyand et al., 2009), their fig. 1B, step #1 of the intact-limb runner.]

model can explain running ground reaction force–time waveforms in their entirety across different speed, foot-strike and footwear conditions.

RESULTS AND DISCUSSION

In keeping with our hypothesis, our two-mass model was able to account for virtually all of the duration, amplitude and force–time pattern variability present in the vertical ground reaction force waveforms analyzed. Despite the large differences in waveform characteristics introduced by different speed, foot-strike and footwear conditions, our model accounted for an average of 97% of the individual force–time relationships (mean $R^2=0.97\pm 0.01$) and a minimum of 95% (Fig. 1). The accuracy of these fits across the heterogeneous waveforms tested suggests that two mechanical phenomena, acting in parallel, are sufficient to explain running ground reaction forces: (1) the collision of the lower limb with the running surface, and (2) the motion of the remainder of the body's mass throughout the stance phase.

The accuracy of the fits achieved using a model with only two mass components and with mass component values held constant across conditions differs from prevailing paradigms in several respects. First, while the sequential additions of third, fourth and fifth mass components to multi-mass models over the last two decades (Liu and Nigg, 2000; Ly et al., 2010; Nigg and Liu, 1999; Nikooyan and Zadpoor, 2011; Zadpoor and Nikooyan, 2010) may describe physical and mechanical reality as theorized (Nigg, 2010; Zadpoor and Nikooyan, 2010), these additional masses may also be unnecessary for waveform prediction. Second, the conclusion that the mass quantity decelerated upon foot–ground impact differs substantially for rear foot versus forefoot impacts (Lieberman et al., 2010; Nigg, 2010) should be reconsidered. The close fits we report here using a constant value of 8.0% of the body's mass across all foot-strike conditions indicates that a variable ‘effective mass’ may be unnecessary for accurate modeling and could be mechanically incorrect. For example, if we predict the sprint running waveform analyzed here (Fig. 1G,H) using the effective mass proportions suggested for a forefoot impact [$m_1=1.7\%$ and $m_2=98.3\%$ of total body mass M_b (Lieberman et al., 2010)] with a speed-specific foot collisional velocity (Mann and Herman, 1985) (Table 1), the rising edge of the sprint waveform is substantially under-predicted and the overall goodness of fit is considerably reduced ($R^2=0.95$ to 0.82; see supplementary material Fig. S1). Third, the model's general features and simplifying assumptions permit impulse J_1 and J_2 durations and forces to be independent. In contrast, the dual ‘stacked spring-mass’ model-type (Alexander, 1990; Derrick et al., 2000; Ker et al., 1989) that Alexander originally introduced (Alexander, 1988) uses a serial, coupled configuration that may be incapable of predicting the brief simultaneous impulses responsible for the characteristic pattern of sprint running waveforms.

Indeed, the model's design was essential for achieving close fits to waveforms with variable rising edges, smooth falling edges and significantly different durations. Given the fixed-mass value of our lower-limb mass component, the close fits to the variable rising edges were achieved predominantly via the two model inputs (Table 1) responsible for the shape of collisional impulse J_1 (Fig. 1). Values for the first of the two, the vertical velocity of the lower limb at touchdown, are well-supported by the waveform-specific literature values available. Values for the second, the deceleration time of the lower limb upon touchdown, are well-supported by the detailed analysis of Nigg et al. (Nigg et al., 1987) for waveform 2, but are lacking for the other three. Fits along the smoother falling edges depend directly upon impulse J_2 because

Table 1. Waveform information

Waveform	Reference	Fig. 1 panels	Speed (m s ⁻¹)	Foot-strike	Shod condition	Mass (kg)	t _c (s)	t _a (s)	Δt ₁ (s)	v _{zlimb} at touchdown (m s ⁻¹)	
										Model	Published
1	Lieberman et al., 2010	A, B	3.5	Fore-foot	Barefoot	70.00	0.251	0.087	0.070	-0.80	-0.80 ^a
2	Weyand et al., 2000	C, D	5.0	Rear foot	Shod	72.06	0.181	0.136	0.025	-1.70	-1.60 ^b
3	Weyand et al., 2010	E, F	5.0	Fore-foot	Shod	69.21	0.182	0.152	0.040	-1.70	-1.60 ^b
4	Weyand et al., 2009	G, H	10.5	Fore-foot	Shod	69.21	0.091	0.136	0.025	-3.10	-3.00 ^c

t_c, contact time; t_a, aerial time; Δt₁, time interval between touchdown and vertical velocity of component m₁ slowing to zero; v_{zlimb}, vertical velocity of lower limb.

^aData from Nigg et al. (Nigg et al., 1987), table 1 in their appendix; listed value is -0.80 m s⁻¹ at running speed of 3.0 m s⁻¹.

^bData from Nigg et al. (Nigg et al., 1987), table 1 in their appendix.

^cData derived from Mann and Herman (Mann and Herman, 1985); listed value is a horizontal foot velocity of -7.93 m s⁻¹ at a running speed of 10.21 m s⁻¹.

of the early conclusion of the J₁ collisional event. Given a known physical basis for determining total impulse J_T from contact and step times (Eqn 1; see Materials and methods), correctly quantifying impulse J₂ depends solely on the quantity subtracted for impulse J₁ (Eqn 2). While empirical validation clearly remains for several elements of our model, the fits achieved using anatomical mass inputs, realistic lower-limb velocities, and one mechanical explanation across conditions raise the possibility that the running force–motion relationship may be more general than previously recognized.

An additional factor in the accuracy of the fits we report was undoubtedly the model evaluation method adopted. The method chosen allowed us to assess a greater variety of waveforms than would have been possible via direct experimentation, but also involved two potential limitations. First, because the model fits were generated by varying the inputs, the goodness-of-fit values obtained should be regarded as the upper performance limits of the model. Second, the digitizing process enabling our approach might have transformed the literature waveforms into more model-conducive shapes. We were able to evaluate this second possibility empirically by applying the inputs used to fit two of the digitized waveforms (3 and 4) to the original waveform data. This process yielded fits that were the same or slightly greater for the original (respective R² values of 0.98 and 0.96) versus digitized versions because the original waveforms were so closely reproduced by digitizing (see supplementary material Tables S1–S4).

We close by providing respective, illustrative examples of the basic and applied advances made possible by the concise physical basis of our two-mass model. One basic insight provided by the framework of the model is the identification of a mechanical strategy that runners can adopt to achieve faster speeds. By simply increasing the lower limb's velocity prior to touchdown, and reducing deceleration time during impact, runners can elevate the collisional impulse (J₁) and total ground reaction forces as needed to attain faster speeds (Weyand et al., 2000; Weyand et al., 2009; Weyand et al., 2010). Both the existing literature data (Table 1) and our modeling results (Fig. 1) are consistent with this being a primary mechanism by which faster human runners do, in fact, attain faster sprint running speeds.

In application, the conciseness of the model could translate into practical techniques for determining ground reaction forces indirectly. At present, the lone indirect assessment method available (Bobbert et al., 1991) is scientifically rigorous, but impractical for broad usage. The existing technique involves the instantaneous summation of the accelerations of seven body segments based on high-frequency positional data from 10 bodily locations. In contrast, the scientific basis of our two-mass model (Eqns 1–6) reduces the data needed for indirect force determinations to three basic

variables: aerial time, contact time and the vertical velocity of the lower limb. Thus, our model may allow video and other motion capture techniques to become practical tools for determining vertical ground reaction forces without direct measurement.

MATERIALS AND METHODS

Model formulation

Because the net vertical displacement of the body over time during steady-speed, level running is zero, the time-averaged vertical ground reaction force must equal the body's weight. Thus, the total stance-averaged vertical force F_{Tavg} can be determined if foot–ground contact time t_c and aerial time t_a are known:

$$F_{Tavg} = mg \frac{t_{step}}{t_c}, \quad (1)$$

where t_{step} is step time (t_{step}=t_c+t_a), m is body mass and g is gravitational acceleration (9.8 m s⁻²).

The ground reaction force waveform represents the instantaneous acceleration of the body's mass. Accordingly, the waveform can be conceptualized as the sum of the instantaneous accelerations of different segments that make up the body's total mass (Bobbert et al., 1991). In our model (Fig. 1), impulse J₁ results from the acceleration of the lower limb during surface impact, and J₂ corresponds to the acceleration of the remainder of the body's mass. The total impulse J_T is the sum of J₁ and J₂:

$$J_T = J_1 + J_2 = F_{Tavg} t_c. \quad (2)$$

Impulse mass m₁ is the 8.0% of the body's total mass attributed to the lower limb, while impulse mass m₂ is the remaining 92.0%. Impulse J₁ is quantified from the deceleration of m₁ during surface impact:

$$J_1 = F_{Tavg}(2\Delta t_1) = m_1 \left(\frac{\Delta v_1}{\Delta t_1} + g \right) (2\Delta t_1), \quad (3)$$

where Δt₁ is the time interval between touchdown and vertical velocity of m₁ slowing to zero, Δv₁ is the change in vertical velocity of m₁ during Δt₁, and F_{Tavg} is the average force during the total time interval (2Δt₁) of impulse J₁. After the J₁ time interval, the model assumes F_{Tavg}=0. J₂ is determined from J₁ and total impulse J_T as:

$$J_2 = J_T - J_1 = F_{Tavg} t_c, \quad (4)$$

where F_{Tavg} is the average force of J₂ during the interval t_c.

Modeled waveforms

The bell-shaped force curves F(t) for J₁ and J₂ are a result of non-linear elastic collisions (Cross, 1999) that can be accurately modeled using the raised cosine function:

$$F(t) = \begin{cases} \frac{A}{2} \left[1 + \cos \left(\frac{t-B}{C} \pi \right) \right] & \text{for } B-C \leq t \leq B+C \\ 0 & \text{for } t < B-C \text{ and } t > B+C \end{cases}, \quad (5)$$

where A is the peak amplitude, B is the center time of the peak and C is the half-width time interval. Because of the symmetrical properties of this

function, peak amplitude $A=2F_{\text{avg}}$, and the area under the curve is $J=AC$. The total force waveform $F_T(t)$ is the sum of each impulse waveform:

$$F_T(t) = \frac{A_1}{2} \left[1 + \cos\left(\frac{t-B_1}{C_1}\pi\right) \right] + \frac{A_2}{2} \left[1 + \cos\left(\frac{t-B_2}{C_2}\pi\right) \right]. \quad (6)$$

A_1 is calculated from $F_{1\text{avg}}$ using the Δv_1 and Δt_1 terms in Eqn 3, and B_1 and C_1 equal the time Δt_1 after touchdown for the vertical velocity of m_1 to reach zero. A_2 is calculated from $F_{2\text{avg}}$ in Eqn 4, and B_2 and C_2 equal one-half the contact time t_c .

Modeled versus actual waveforms

We digitized (Engauge, version 4.1) four published waveforms that varied in duration, amplitude and shape (Table 1). Model fits of the four digitized waveforms (Fig. 1) were performed via a manual iterative process that constrained the inputs for Δt_1 and Δv_1 to values deemed realistic on the basis of existing literature. Inputs for t_c and subsequent t_a were determined from the waveforms using a threshold of 60 N. In two cases (waveforms 3 and 4), goodness of fit between modeled and original data waveforms were determined to supplement the evaluation of the digitized versions.

Model fits were quantified in two ways: (1) in force units standardized to the body's weight (W_b) using the root mean square statistic (RMSE), and (2) for goodness of fit using the R^2 statistic. Digitized waveforms were interpolated as needed to provide force data on a per millisecond basis for these analyses. We hypothesized that the model would explain 90% or more (i.e. $R^2 \geq 0.90$) of the force-time variation present in each of the four waveforms analyzed. Data for all digitized, modeled and original waveforms used in the analysis are provided in supplementary material Tables S1–S4.

All variables are presented in SI units, but, per convention, force waveforms are illustrated in mass-specific units.

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Competing interests

The authors declare competing financial interests. Peter Weyand, Laurence Ryan and Kenneth Clark are the inventors of US Patent #8363891 which is owned by Southern Methodist University and contains scientific content related to that presented in the paper. The patent is licensed to SoleForce LLC in which the three aforementioned individuals are equity partners.

Author contributions

Each of the three authors, K.P.C., L.J.R. and P.G.W., contributed substantially to the conception of the study, the implementation and evaluation of the model presented, and the writing of the manuscript.

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Supplementary material

Supplementary material available online at
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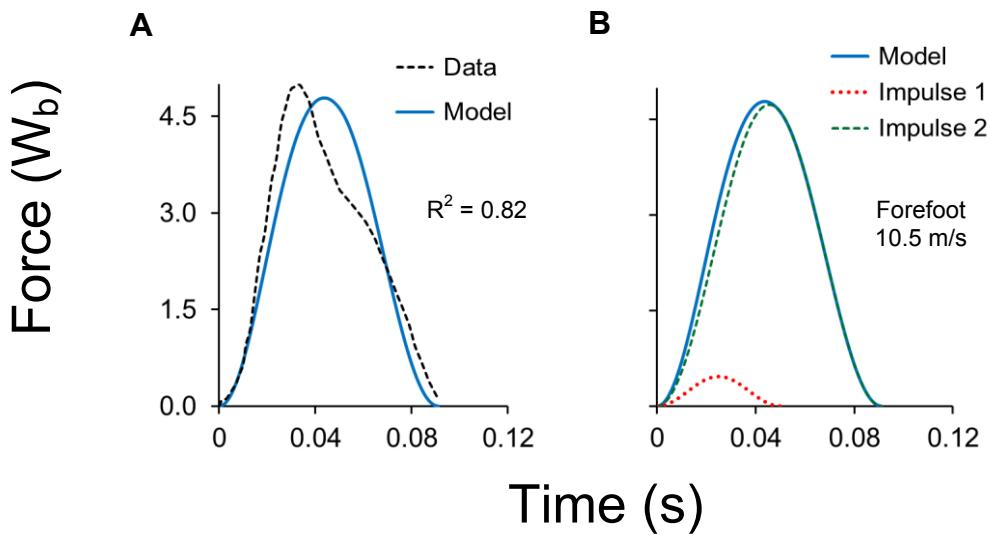


Fig. S1. Actual vs. modeled ground reaction force vs. time waveform (A) for a sprint running step (Table 1, waveform number 4). The goodness of fit above is less accurate than the originally presented model prediction (Fig. 1H, $R^2=0.95$) as a result of the smaller mass percentage assigned to m_1 (1.5 vs. 8.0%) and greater percentage assigned to m_2 (98.5 vs. 92.0%). The poorer fit resulting from these mass percentage reassessments was due to the combined effects of a smaller J_1 impulse and larger J_2 impulse (B) vs. the original (Fig. 1I). The predictive error, expressed in force units standardized to the body's weight, was approximately twice as large for the waveform predicted above vs. the original prediction (0.67 vs. 0.35 W_b). [Note: The m_1 'effective mass' value of 1.5% used above was the value suggested by Lieberman et al. (Lieberman et al., 2010) for forefoot impacts.]

Supplementary Table 1

Figure Panel: 1A and 1B

Reference Publication: Lieberman et al. (2009)

Reference Publication Figure: Figure 1c, Step #1

Speed (m/s): 3.5

Footwear Condition: Barefoot

Foot-Strike Type: Fore-Foot

Runner's Assigned Mass (kg): 70.00

Time (s)	Impulse 1 Force (W _b)	Impulse 2 Force (W _b)	Total Model Force (W _b)	Digitized Force (W _b)		Time (s)	Impulse 1 Force (N)	Impulse 2 Force (N)	Total Model Force (N)	Digitized Force (N)
0.000	0.0000	0.0000	0.0000	0.0000		0.000	0.0000	0.0000	0.0000	0.0000
0.001	0.0002	0.0004	0.0006	0.0886		0.001	0.1197	0.2686	0.3883	60.7765
0.002	0.0007	0.0016	0.0023	0.0924		0.002	0.4786	1.0744	1.5530	63.4058
0.003	0.0016	0.0035	0.0051	0.0963		0.003	1.0759	2.4168	3.4927	66.0351
0.004	0.0028	0.0063	0.0090	0.1001		0.004	1.9105	4.2949	6.2054	68.6644
0.005	0.0043	0.0098	0.0141	0.1039		0.005	2.9806	6.7077	9.6883	71.2937
0.006	0.0062	0.0141	0.0203	0.1078		0.006	4.2841	9.6535	13.9376	73.9230
0.007	0.0085	0.0191	0.0276	0.1116		0.007	5.8184	13.1306	18.9490	76.5522
0.008	0.0111	0.0250	0.0360	0.1285		0.008	7.5804	17.1368	24.7172	88.1689
0.009	0.0139	0.0316	0.0455	0.1511		0.009	9.5665	21.6695	31.2360	103.6851

0.010	0.0172	0.0390	0.0561	0.1738		0.010	11.7728	26.7259	38.4987	119.2014
0.011	0.0207	0.0471	0.0678	0.1964		0.011	14.1948	32.3028	46.4976	134.7176
0.012	0.0245	0.0560	0.0805	0.2190		0.012	16.8276	38.3968	55.2244	150.2339
0.013	0.0287	0.0656	0.0943	0.2416		0.013	19.6659	45.0040	64.6700	165.7501
0.014	0.0331	0.0760	0.1091	0.2649		0.014	22.7041	52.1204	74.8244	181.7523
0.015	0.0378	0.0871	0.1249	0.2900		0.015	25.9359	59.7413	85.6772	198.9548
0.016	0.0428	0.0989	0.1417	0.3151		0.016	29.3549	67.8621	97.2170	216.1573
0.017	0.0480	0.1115	0.1595	0.3402		0.017	32.9541	76.4777	109.4318	233.3598
0.018	0.0535	0.1248	0.1783	0.3653		0.018	36.7265	85.5826	122.3091	250.5623
0.019	0.0593	0.1387	0.1980	0.3903		0.019	40.6642	95.1712	135.8355	267.7648
0.020	0.0652	0.1534	0.2187	0.4154		0.020	44.7595	105.2375	149.9970	284.9673
0.021	0.0714	0.1688	0.2402	0.4478		0.021	49.0041	115.7751	164.7792	307.2244
0.022	0.0778	0.1848	0.2626	0.4814		0.022	53.3894	126.7774	180.1668	330.2712
0.023	0.0844	0.2015	0.2859	0.5150		0.023	57.9065	138.2376	196.1442	353.3179
0.024	0.0912	0.2189	0.3101	0.5486		0.024	62.5465	150.1485	212.6950	376.3647
0.025	0.0981	0.2369	0.3350	0.5775		0.025	67.2999	162.5026	229.8025	396.1978
0.026	0.1052	0.2555	0.3607	0.6026		0.026	72.1572	175.2921	247.4493	413.4005
0.027	0.1124	0.2748	0.3872	0.6277		0.027	77.1086	188.5091	265.6177	430.6033
0.028	0.1197	0.2947	0.4144	0.6528		0.028	82.1441	202.1453	284.2893	447.8061
0.029	0.1272	0.3151	0.4423	0.6779		0.029	87.2535	216.1921	303.4456	465.0088
0.030	0.1347	0.3362	0.4709	0.7029		0.030	92.4267	230.6407	323.0674	482.2116
0.031	0.1424	0.3578	0.5002	0.7295		0.031	97.6532	245.4821	343.1352	500.4687

0.032	0.1500	0.3800	0.5301	0.7668		0.032	102.9223	260.7069	363.6293	525.9929
0.033	0.1578	0.4028	0.5605	0.8040		0.033	108.2237	276.3057	384.5294	551.5170
0.034	0.1655	0.4260	0.5916	0.8412		0.034	113.5465	292.2686	405.8151	577.0412
0.035	0.1733	0.4498	0.6231	0.8784		0.035	118.8800	308.5857	427.4657	602.5654
0.036	0.1811	0.4741	0.6552	0.9156		0.036	124.2135	325.2468	449.4603	628.0920
0.037	0.1888	0.4989	0.6877	0.9528		0.037	129.5363	342.2413	471.7776	653.6191
0.038	0.1966	0.5241	0.7207	0.9900		0.038	134.8377	359.5586	494.3963	679.1462
0.039	0.2042	0.5498	0.7541	1.0272		0.039	140.1068	377.1880	517.2948	704.6734
0.040	0.2119	0.5760	0.7878	1.0627		0.040	145.3333	395.1183	540.4515	729.0375
0.041	0.2194	0.6025	0.8219	1.0963		0.041	150.5065	413.3383	563.8447	752.0849
0.042	0.2268	0.6295	0.8563	1.1299		0.042	155.6159	431.8365	587.4525	775.1322
0.043	0.2342	0.6569	0.8910	1.1635		0.043	160.6514	450.6015	611.2530	798.1796
0.044	0.2414	0.6846	0.9260	1.1977		0.044	165.6028	469.6215	635.2243	821.6084
0.045	0.2485	0.7127	0.9611	1.2349		0.045	170.4601	488.8844	659.3445	847.1326
0.046	0.2554	0.7411	0.9965	1.2721		0.046	175.2135	508.3783	683.5918	872.6567
0.047	0.2622	0.7698	1.0320	1.3093		0.047	179.8535	528.0910	707.9445	898.1809
0.048	0.2688	0.7988	1.0676	1.3465		0.048	184.3706	548.0100	732.3807	923.7050
0.049	0.2752	0.8282	1.1033	1.3837		0.049	188.7559	568.1230	756.8789	949.2291
0.050	0.2813	0.8578	1.1391	1.4209		0.050	193.0005	588.4172	781.4177	974.7533
0.051	0.2873	0.8876	1.1749	1.4581		0.051	197.0958	608.8801	805.9758	1000.2774
0.052	0.2931	0.9176	1.2107	1.4953		0.052	201.0335	629.4987	830.5322	1025.8016
0.053	0.2986	0.9479	1.2465	1.5325		0.053	204.8059	650.2601	855.0660	1051.3265

0.054	0.3038	0.9784	1.2822	1.5698		0.054	208.4051	671.1514	879.5566	1076.8522
0.055	0.3088	1.0090	1.3178	1.6070		0.055	211.8241	692.1595	903.9836	1102.3780
0.056	0.3135	1.0398	1.3532	1.6442		0.056	215.0559	713.2711	928.3270	1127.9037
0.057	0.3179	1.0707	1.3886	1.6814		0.057	218.0941	734.4731	952.5671	1153.4282
0.058	0.3221	1.1017	1.4237	1.7186		0.058	220.9324	755.7521	976.6845	1178.9464
0.059	0.3259	1.1328	1.4587	1.7558		0.059	223.5652	777.0949	1000.6601	1204.4647
0.060	0.3294	1.1640	1.4934	1.7930		0.060	225.9872	798.4880	1024.4752	1229.9829
0.061	0.3326	1.1952	1.5279	1.8302		0.061	228.1935	819.9181	1048.1116	1255.5012
0.062	0.3355	1.2265	1.5620	1.8644		0.062	230.1796	841.3717	1071.5513	1278.9558
0.063	0.3381	1.2578	1.5959	1.8980		0.063	231.9416	862.8355	1094.7771	1302.0085
0.064	0.3403	1.2891	1.6294	1.9316		0.064	233.4759	884.2958	1117.7717	1325.0612
0.065	0.3422	1.3203	1.6626	1.9652		0.065	234.7794	905.7394	1140.5188	1348.1139
0.066	0.3438	1.3515	1.6953	1.9943		0.066	235.8495	927.1527	1163.0022	1368.1058
0.067	0.3450	1.3827	1.7277	2.0194		0.067	236.6841	948.5223	1185.2064	1385.3059
0.068	0.3459	1.4138	1.7596	2.0445		0.068	237.2814	969.8349	1207.1163	1402.5061
0.069	0.3464	1.4447	1.7911	2.0695		0.069	237.6403	991.0770	1228.7173	1419.7063
0.070	0.3466	1.4756	1.8222	2.0946		0.070	237.7600	1012.2355	1249.9955	1436.9065
0.071	0.3464	1.5063	1.8527	2.1197		0.071	237.6403	1033.2970	1270.9373	1454.1067
0.072	0.3459	1.5368	1.8827	2.1440		0.072	237.2814	1054.2483	1291.5297	1470.7620
0.073	0.3450	1.5672	1.9122	2.1610		0.073	236.6841	1075.0763	1311.7604	1482.4578
0.074	0.3438	1.5973	1.9411	2.1781		0.074	235.8495	1095.7679	1331.6175	1494.1536
0.075	0.3422	1.6273	1.9695	2.1951		0.075	234.7794	1116.3103	1351.0897	1505.8494

0.076	0.3403	1.6570	1.9973	2.2122		0.076	233.4759	1136.6904	1370.1663	1517.5452
0.077	0.3381	1.6864	2.0245	2.2292		0.077	231.9416	1156.8956	1388.8372	1529.2410
0.078	0.3355	1.7156	2.0512	2.2463		0.078	230.1796	1176.9131	1407.0928	1540.9368
0.079	0.3326	1.7445	2.0771	2.2633		0.079	228.1935	1196.7305	1424.9240	1552.6326
0.080	0.3294	1.7731	2.1025	2.2804		0.080	225.9872	1216.3354	1442.3225	1564.3284
0.081	0.3259	1.8013	2.1272	2.2974		0.081	223.5652	1235.7153	1459.2805	1576.0229
0.082	0.3221	1.8292	2.1513	2.3145		0.082	220.9324	1254.8583	1475.7907	1587.7165
0.083	0.3179	1.8568	2.1747	2.3315		0.083	218.0941	1273.7522	1491.8463	1599.4101
0.084	0.3135	1.8839	2.1974	2.3485		0.084	215.0559	1292.3853	1507.4413	1611.1038
0.085	0.3088	1.9107	2.2195	2.3656		0.085	211.8241	1310.7459	1522.5700	1622.7974
0.086	0.3038	1.9371	2.2409	2.3826		0.086	208.4051	1328.8225	1537.2276	1634.4910
0.087	0.2986	1.9630	2.2615	2.3997		0.087	204.8059	1346.6037	1551.4095	1646.1846
0.088	0.2931	1.9885	2.2815	2.4167		0.088	201.0335	1364.0784	1565.1119	1657.8783
0.089	0.2873	2.0135	2.3008	2.4329		0.089	197.0958	1381.2357	1578.3314	1668.9783
0.090	0.2813	2.0380	2.3193	2.4406		0.090	193.0005	1398.0647	1591.0652	1674.2197
0.091	0.2752	2.0620	2.3372	2.4482		0.091	188.7559	1414.5551	1603.3110	1679.4612
0.092	0.2688	2.0856	2.3543	2.4558		0.092	184.3706	1430.6964	1615.0670	1684.7026
0.093	0.2622	2.1086	2.3707	2.4635		0.093	179.8535	1446.4785	1626.3319	1689.9441
0.094	0.2554	2.1310	2.3865	2.4711		0.094	175.2135	1461.8915	1637.1050	1695.1855
0.095	0.2485	2.1530	2.4014	2.4788		0.095	170.4601	1476.9258	1647.3859	1700.4270
0.096	0.2414	2.1743	2.4157	2.4864		0.096	165.6028	1491.5719	1657.1748	1705.6684
0.097	0.2342	2.1951	2.4293	2.4940		0.097	160.6514	1505.8208	1666.4722	1710.9099

0.098	0.2268	2.2153	2.4421	2.5017		0.098	155.6159	1519.6633	1675.2793	1716.1513
0.099	0.2194	2.2348	2.4542	2.5093		0.099	150.5065	1533.0909	1683.5974	1721.3928
0.100	0.2119	2.2538	2.4656	2.5170		0.100	145.3333	1546.0952	1691.4285	1726.6343
0.101	0.2042	2.2721	2.4763	2.5246		0.101	140.1068	1558.6680	1698.7749	1731.8757
0.102	0.1966	2.2898	2.4864	2.5322		0.102	134.8377	1570.8015	1705.6391	1737.1172
0.103	0.1888	2.3068	2.4957	2.5399		0.103	129.5363	1582.4879	1712.0242	1742.3586
0.104	0.1811	2.3232	2.5043	2.5455		0.104	124.2135	1593.7201	1717.9336	1746.2404
0.105	0.1733	2.3389	2.5122	2.5472		0.105	118.8800	1604.4909	1723.3709	1747.4110
0.106	0.1655	2.3539	2.5194	2.5490		0.106	113.5465	1614.7936	1728.3401	1748.5816
0.107	0.1578	2.3683	2.5260	2.5507		0.107	108.2237	1624.6218	1732.8455	1749.7522
0.108	0.1500	2.3819	2.5319	2.5524		0.108	102.9223	1633.9693	1736.8917	1750.9228
0.109	0.1424	2.3948	2.5371	2.5541		0.109	97.6532	1642.8303	1740.4834	1752.0933
0.110	0.1347	2.4070	2.5417	2.5558		0.110	92.4267	1651.1991	1743.6258	1753.2639
0.111	0.1272	2.4185	2.5457	2.5575		0.111	87.2535	1659.0706	1746.3241	1754.4345
0.112	0.1197	2.4292	2.5490	2.5592		0.112	82.1441	1666.4398	1748.5839	1755.6051
0.113	0.1124	2.4392	2.5516	2.5609		0.113	77.1086	1673.3021	1750.4107	1756.7757
0.114	0.1052	2.4485	2.5537	2.5626		0.114	72.1572	1679.6532	1751.8104	1757.9463
0.115	0.0981	2.4570	2.5551	2.5643		0.115	67.2999	1685.4892	1752.7891	1759.1169
0.116	0.0912	2.4647	2.5559	2.5660		0.116	62.5465	1690.8063	1753.3527	1760.2875
0.117	0.0844	2.4717	2.5561	2.5677		0.117	57.9065	1695.6012	1753.5077	1761.4581
0.118	0.0778	2.4779	2.5558	2.5694		0.118	53.3894	1699.8709	1753.2603	1762.6287
0.119	0.0714	2.4834	2.5548	2.5711		0.119	49.0041	1703.6128	1752.6169	1763.7992

0.120	0.0652	2.4881	2.5533	2.5728		0.120	44.7595	1706.8245	1751.5841	1764.9698
0.121	0.0593	2.4920	2.5513	2.5745		0.121	40.6642	1709.5041	1750.1683	1766.1404
0.122	0.0535	2.4951	2.5487	2.5763		0.122	36.7265	1711.6497	1748.3762	1767.3110
0.123	0.0480	2.4975	2.5455	2.5731		0.123	32.9541	1713.2601	1746.2142	1765.1623
0.124	0.0428	2.4990	2.5418	2.5643		0.124	29.3549	1714.3342	1743.6891	1759.0856
0.125	0.0378	2.4998	2.5376	2.5554		0.125	25.9359	1714.8715	1740.8074	1753.0089
0.126	0.0331	2.4998	2.5329	2.5465		0.126	22.7041	1714.8715	1737.5755	1746.9322
0.127	0.0287	2.4990	2.5277	2.5377		0.127	19.6659	1714.3342	1734.0002	1740.8555
0.128	0.0245	2.4975	2.5220	2.5288		0.128	16.8276	1713.2601	1730.0877	1734.7788
0.129	0.0207	2.4951	2.5158	2.5200		0.129	14.1948	1711.6497	1725.8445	1728.7021
0.130	0.0172	2.4920	2.5091	2.5111		0.130	11.7728	1709.5041	1721.2769	1722.6253
0.131	0.0139	2.4881	2.5020	2.5023		0.131	9.5665	1706.8245	1716.3911	1716.5486
0.132	0.0111	2.4834	2.4945	2.4934		0.132	7.5804	1703.6128	1711.1932	1710.4719
0.133	0.0085	2.4779	2.4864	2.4845		0.133	5.8184	1699.8709	1705.6893	1704.3952
0.134	0.0062	2.4717	2.4780	2.4757		0.134	4.2841	1695.6012	1699.8853	1698.3185
0.135	0.0043	2.4647	2.4691	2.4668		0.135	2.9806	1690.8063	1693.7868	1692.2418
0.136	0.0028	2.4570	2.4598	2.4580		0.136	1.9105	1685.4892	1687.3996	1686.1651
0.137	0.0016	2.4485	2.4500	2.4491		0.137	1.0759	1679.6532	1680.7291	1680.0883
0.138	0.0007	2.4392	2.4399	2.4370		0.138	0.4786	1673.3021	1673.7807	1671.7736
0.139	0.0002	2.4292	2.4294	2.4245		0.139	0.1197	1666.4398	1666.5595	1663.2401
0.140	0.0000	2.4185	2.4185	2.4121		0.140	0.0000	1659.0706	1659.0706	1654.7067
0.141	0.0000	2.4070	2.4070	2.3997		0.141	0.0000	1651.1991	1651.1991	1646.1732

0.142	0.0000	2.3948	2.3948	2.3872		0.142	0.0000	1642.8303	1642.8303	1637.6398
0.143	0.0000	2.3819	2.3819	2.3748		0.143	0.0000	1633.9693	1633.9693	1629.1063
0.144	0.0000	2.3683	2.3683	2.3624		0.144	0.0000	1624.6218	1624.6218	1620.5729
0.145	0.0000	2.3539	2.3539	2.3499		0.145	0.0000	1614.7936	1614.7936	1612.0394
0.146	0.0000	2.3389	2.3389	2.3375		0.146	0.0000	1604.4909	1604.4909	1603.5060
0.147	0.0000	2.3232	2.3232	2.3250		0.147	0.0000	1593.7201	1593.7201	1594.9725
0.148	0.0000	2.3068	2.3068	2.3050		0.148	0.0000	1582.4879	1582.4879	1581.2191
0.149	0.0000	2.2898	2.2898	2.2788		0.149	0.0000	1570.8015	1570.8015	1563.2292
0.150	0.0000	2.2721	2.2721	2.2525		0.150	0.0000	1558.6680	1558.6680	1545.2393
0.151	0.0000	2.2538	2.2538	2.2263		0.151	0.0000	1546.0952	1546.0952	1527.2494
0.152	0.0000	2.2348	2.2348	2.2001		0.152	0.0000	1533.0909	1533.0909	1509.2595
0.153	0.0000	2.2153	2.2153	2.1739		0.153	0.0000	1519.6633	1519.6633	1491.2696
0.154	0.0000	2.1951	2.1951	2.1512		0.154	0.0000	1505.8208	1505.8208	1475.7138
0.155	0.0000	2.1743	2.1743	2.1336		0.155	0.0000	1491.5719	1491.5719	1463.6608
0.156	0.0000	2.1530	2.1530	2.1160		0.156	0.0000	1476.9258	1476.9258	1451.6078
0.157	0.0000	2.1310	2.1310	2.0985		0.157	0.0000	1461.8915	1461.8915	1439.5548
0.158	0.0000	2.1086	2.1086	2.0809		0.158	0.0000	1446.4785	1446.4785	1427.5017
0.159	0.0000	2.0856	2.0856	2.0633		0.159	0.0000	1430.6964	1430.6964	1415.4487
0.160	0.0000	2.0620	2.0620	2.0458		0.160	0.0000	1414.5551	1414.5551	1403.3957
0.161	0.0000	2.0380	2.0380	2.0282		0.161	0.0000	1398.0647	1398.0647	1391.3427
0.162	0.0000	2.0135	2.0135	2.0093		0.162	0.0000	1381.2357	1381.2357	1378.3457
0.163	0.0000	1.9885	1.9885	1.9830		0.163	0.0000	1364.0784	1364.0784	1360.3558

0.164	0.0000	1.9630	1.9630	1.9568		0.164	0.0000	1346.6037	1346.6037	1342.3659
0.165	0.0000	1.9371	1.9371	1.9306		0.165	0.0000	1328.8225	1328.8225	1324.3760
0.166	0.0000	1.9107	1.9107	1.9044		0.166	0.0000	1310.7459	1310.7459	1306.3861
0.167	0.0000	1.8839	1.8839	1.8781		0.167	0.0000	1292.3853	1292.3853	1288.3962
0.168	0.0000	1.8568	1.8568	1.8519		0.168	0.0000	1273.7522	1273.7522	1270.4375
0.169	0.0000	1.8292	1.8292	1.8284		0.169	0.0000	1254.8583	1254.8583	1254.2826
0.170	0.0000	1.8013	1.8013	1.8049		0.170	0.0000	1235.7153	1235.7153	1238.1277
0.171	0.0000	1.7731	1.7731	1.7813		0.171	0.0000	1216.3354	1216.3354	1221.9728
0.172	0.0000	1.7445	1.7445	1.7578		0.172	0.0000	1196.7305	1196.7305	1205.8180
0.173	0.0000	1.7156	1.7156	1.7342		0.173	0.0000	1176.9131	1176.9131	1189.6631
0.174	0.0000	1.6864	1.6864	1.7107		0.174	0.0000	1156.8956	1156.8956	1173.5082
0.175	0.0000	1.6570	1.6570	1.6731		0.175	0.0000	1136.6904	1136.6904	1147.7609
0.176	0.0000	1.6273	1.6273	1.6333		0.176	0.0000	1116.3103	1116.3103	1120.4649
0.177	0.0000	1.5973	1.5973	1.5935		0.177	0.0000	1095.7679	1095.7679	1093.1690
0.178	0.0000	1.5672	1.5672	1.5538		0.178	0.0000	1075.0763	1075.0763	1065.8730
0.179	0.0000	1.5368	1.5368	1.5272		0.179	0.0000	1054.2483	1054.2483	1047.6347
0.180	0.0000	1.5063	1.5063	1.5036		0.180	0.0000	1033.2970	1033.2970	1031.4799
0.181	0.0000	1.4756	1.4756	1.4801		0.181	0.0000	1012.2355	1012.2355	1015.3250
0.182	0.0000	1.4447	1.4447	1.4565		0.182	0.0000	991.0770	991.0770	999.1701
0.183	0.0000	1.4138	1.4138	1.4330		0.183	0.0000	969.8349	969.8349	983.0152
0.184	0.0000	1.3827	1.3827	1.4094		0.184	0.0000	948.5223	948.5223	966.8604
0.185	0.0000	1.3515	1.3515	1.3841		0.185	0.0000	927.1527	927.1527	949.4999

0.186	0.0000	1.3203	1.3203	1.3579		0.186	0.0000	905.7394	905.7394	931.5100
0.187	0.0000	1.2891	1.2891	1.3317		0.187	0.0000	884.2958	884.2958	913.5201
0.188	0.0000	1.2578	1.2578	1.3054		0.188	0.0000	862.8355	862.8355	895.5301
0.189	0.0000	1.2265	1.2265	1.2792		0.189	0.0000	841.3717	841.3717	877.5402
0.190	0.0000	1.1952	1.1952	1.2530		0.190	0.0000	819.9181	819.9181	859.5503
0.191	0.0000	1.1640	1.1640	1.2268		0.191	0.0000	798.4880	798.4880	841.5614
0.192	0.0000	1.1328	1.1328	1.2005		0.192	0.0000	777.0949	777.0949	823.5733
0.193	0.0000	1.1017	1.1017	1.1743		0.193	0.0000	755.7521	755.7521	805.5852
0.194	0.0000	1.0707	1.0707	1.1481		0.194	0.0000	734.4731	734.4731	787.5971
0.195	0.0000	1.0398	1.0398	1.1219		0.195	0.0000	713.2711	713.2711	769.6090
0.196	0.0000	1.0090	1.0090	1.0957		0.196	0.0000	692.1595	692.1595	751.6209
0.197	0.0000	0.9784	0.9784	1.0659		0.197	0.0000	671.1514	671.1514	731.2172
0.198	0.0000	0.9479	0.9479	1.0302		0.198	0.0000	650.2601	650.2601	706.7357
0.199	0.0000	0.9176	0.9176	0.9945		0.199	0.0000	629.4987	629.4987	682.2542
0.200	0.0000	0.8876	0.8876	0.9589		0.200	0.0000	608.8801	608.8801	657.7727
0.201	0.0000	0.8578	0.8578	0.9261		0.201	0.0000	588.4172	588.4172	635.3034
0.202	0.0000	0.8282	0.8282	0.8999		0.202	0.0000	568.1230	568.1230	617.3130
0.203	0.0000	0.7988	0.7988	0.8736		0.203	0.0000	548.0100	548.0100	599.3227
0.204	0.0000	0.7698	0.7698	0.8474		0.204	0.0000	528.0910	528.0910	581.3323
0.205	0.0000	0.7411	0.7411	0.8212		0.205	0.0000	508.3783	508.3783	563.3420
0.206	0.0000	0.7127	0.7127	0.7950		0.206	0.0000	488.8844	488.8844	545.3516
0.207	0.0000	0.6846	0.6846	0.7692		0.207	0.0000	469.6215	469.6215	527.6697

0.208	0.0000	0.6569	0.6569	0.7456		0.208	0.0000	450.6015	450.6015	511.5153
0.209	0.0000	0.6295	0.6295	0.7221		0.209	0.0000	431.8365	431.8365	495.3608
0.210	0.0000	0.6025	0.6025	0.6986		0.210	0.0000	413.3383	413.3383	479.2064
0.211	0.0000	0.5760	0.5760	0.6750		0.211	0.0000	395.1183	395.1183	463.0520
0.212	0.0000	0.5498	0.5498	0.6515		0.212	0.0000	377.1880	377.1880	446.8975
0.213	0.0000	0.5241	0.5241	0.6279		0.213	0.0000	359.5586	359.5586	430.7211
0.214	0.0000	0.4989	0.4989	0.6016		0.214	0.0000	342.2413	342.2413	412.7307
0.215	0.0000	0.4741	0.4741	0.5754		0.215	0.0000	325.2468	325.2468	394.7404
0.216	0.0000	0.4498	0.4498	0.5492		0.216	0.0000	308.5857	308.5857	376.7500
0.217	0.0000	0.4260	0.4260	0.5230		0.217	0.0000	292.2686	292.2686	358.7597
0.218	0.0000	0.4028	0.4028	0.4967		0.218	0.0000	276.3057	276.3057	340.7693
0.219	0.0000	0.3800	0.3800	0.4705		0.219	0.0000	260.7069	260.7069	322.7790
0.220	0.0000	0.3578	0.3578	0.4518		0.220	0.0000	245.4821	245.4821	309.9544
0.221	0.0000	0.3362	0.3362	0.4343		0.221	0.0000	230.6407	230.6407	297.9017
0.222	0.0000	0.3151	0.3151	0.4167		0.222	0.0000	216.1921	216.1921	285.8490
0.223	0.0000	0.2947	0.2947	0.3991		0.223	0.0000	202.1453	202.1453	273.7963
0.224	0.0000	0.2748	0.2748	0.3816		0.224	0.0000	188.5091	188.5091	261.7436
0.225	0.0000	0.2555	0.2555	0.3640		0.225	0.0000	175.2921	175.2921	249.6910
0.226	0.0000	0.2369	0.2369	0.3464		0.226	0.0000	162.5026	162.5026	237.6383
0.227	0.0000	0.2189	0.2189	0.3288		0.227	0.0000	150.1485	150.1485	225.5856
0.228	0.0000	0.2015	0.2015	0.3144		0.228	0.0000	138.2376	138.2376	215.7109
0.229	0.0000	0.1848	0.1848	0.3020		0.229	0.0000	126.7774	126.7774	207.1767

0.230	0.0000	0.1688	0.1688	0.2896		0.230	0.0000	115.7751	115.7751	198.6425
0.231	0.0000	0.1534	0.1534	0.2771		0.231	0.0000	105.2375	105.2375	190.1082
0.232	0.0000	0.1387	0.1387	0.2647		0.232	0.0000	95.1712	95.1712	181.5740
0.233	0.0000	0.1248	0.1248	0.2522		0.233	0.0000	85.5826	85.5826	173.0398
0.234	0.0000	0.1115	0.1115	0.2398		0.234	0.0000	76.4777	76.4777	164.5056
0.235	0.0000	0.0989	0.0989	0.2274		0.235	0.0000	67.8621	67.8621	155.9714
0.236	0.0000	0.0871	0.0871	0.2149		0.236	0.0000	59.7413	59.7413	147.4372
0.237	0.0000	0.0760	0.0760	0.2025		0.237	0.0000	52.1204	52.1204	138.9030
0.238	0.0000	0.0656	0.0656	0.1913		0.238	0.0000	45.0040	45.0040	131.2099
0.239	0.0000	0.0560	0.0560	0.1835		0.239	0.0000	38.3968	38.3968	125.8983
0.240	0.0000	0.0471	0.0471	0.1758		0.240	0.0000	32.3028	32.3028	120.5867
0.241	0.0000	0.0390	0.0390	0.1680		0.241	0.0000	26.7259	26.7259	115.2750
0.242	0.0000	0.0316	0.0316	0.1603		0.242	0.0000	21.6695	21.6695	109.9634
0.243	0.0000	0.0250	0.0250	0.1526		0.243	0.0000	17.1368	17.1368	104.6518
0.244	0.0000	0.0191	0.0191	0.1448		0.244	0.0000	13.1306	13.1306	99.3401
0.245	0.0000	0.0141	0.0141	0.1371		0.245	0.0000	9.6535	9.6535	94.0285
0.246	0.0000	0.0098	0.0098	0.1293		0.246	0.0000	6.7077	6.7077	88.7169
0.247	0.0000	0.0063	0.0063	0.1216		0.247	0.0000	4.2949	4.2949	83.4053
0.248	0.0000	0.0035	0.0035	0.1138		0.248	0.0000	2.4168	2.4168	78.0936
0.249	0.0000	0.0016	0.0016	0.1061		0.249	0.0000	1.0744	1.0744	72.7820
0.250	0.0000	0.0004	0.0004	0.0984		0.250	0.0000	0.2686	0.2686	67.4704
0.251	0.0000	0.0000	0.0000	0.0906		0.251	0.0000	0.0000	0.0000	62.1587

Supplementary Table 2

Figure Panel: 1C and 1D

Reference Publication: Weyand et al. (2000)

Reference Publication Figure: Figure 1B, Step #2

Speed (m/s): 5.0

Footwear Condition: Shod

Foot-Strike Type: Rear-Foot

Runner's Mass (kg): 72.06

Time (s)	Impulse 1 Force (W _b)	Impulse 2 Force (W _b)	Total Model Force (W _b)	Digitized Force (W _b)		Time (s)	Impulse 1 Force (N)	Impulse 2 Force (N)	Total Model Force (N)	Digitized Force (N)
0.000	0.0000	0.0000	0.0000	0.0000		0.000	0.0000	0.0000	0.0000	0.0000
0.001	0.0050	0.0009	0.0060	0.1087		0.001	3.5364	0.6704	4.2068	76.7241
0.002	0.0200	0.0038	0.0237	0.1344		0.002	14.0897	2.6810	16.7706	94.8833
0.003	0.0446	0.0085	0.0531	0.1601		0.003	31.4935	6.0292	37.5227	113.0425
0.004	0.0786	0.0152	0.0937	0.1690		0.004	55.4734	10.7110	66.1844	119.3461
0.005	0.1213	0.0237	0.1450	0.1766		0.005	85.6511	16.7208	102.3719	124.7298
0.006	0.1721	0.0341	0.2062	0.1843		0.006	121.5509	24.0513	145.6022	130.1135
0.007	0.2303	0.0463	0.2766	0.1919		0.007	162.6064	32.6938	195.3001	135.4972
0.008	0.2948	0.0604	0.3552	0.1995		0.008	208.1702	42.6377	250.8079	140.8809
0.009	0.3647	0.0763	0.4410	0.2071		0.009	257.5238	53.8712	311.3949	146.2646

0.010	0.4388	0.0940	0.5328	0.2425		0.010	309.8887	66.3806	376.2694	171.2737
0.011	0.5161	0.1135	0.6296	0.2910		0.011	364.4393	80.1510	444.5903	205.4760
0.012	0.5952	0.1348	0.7300	0.3444		0.012	420.3152	95.1656	515.4808	243.1994
0.013	0.6750	0.1578	0.8327	0.4046		0.013	476.6352	111.4065	588.0417	285.7365
0.014	0.7541	0.1825	0.9366	0.5040		0.014	532.5111	128.8541	661.3651	355.8951
0.015	0.8314	0.2089	1.0402	0.6074		0.015	587.0617	147.4872	734.5489	428.9254
0.016	0.9055	0.2369	1.1424	0.6731		0.016	639.4267	167.2836	806.7102	475.3100
0.017	0.9754	0.2665	1.2420	0.8228		0.017	688.7802	188.2193	876.9995	581.0105
0.018	1.0399	0.2978	1.3377	0.9318		0.018	734.3441	210.2690	944.6131	657.9920
0.019	1.0981	0.3305	1.4286	1.0434		0.019	775.3996	233.4063	1008.8059	736.8071
0.020	1.1489	0.3648	1.5137	1.1582		0.020	811.2993	257.6033	1068.9026	817.8580
0.021	1.1916	0.4005	1.5922	1.3237		0.021	841.4770	282.8308	1124.3078	934.7034
0.022	1.2256	0.4377	1.6633	1.4136		0.022	865.4569	309.0583	1174.5152	998.2222
0.023	1.2503	0.4762	1.7264	1.5682		0.023	882.8607	336.2544	1219.1151	1107.3758
0.024	1.2652	0.5160	1.7812	1.7502		0.024	893.4141	364.3862	1257.8002	1235.8997
0.025	1.2702	0.5571	1.8273	1.8643		0.025	896.9504	393.4198	1290.3702	1316.4507
0.026	1.2652	0.5995	1.8647	1.9751		0.026	893.4141	423.3203	1316.7343	1394.7068
0.027	1.2503	0.6430	1.8933	2.0236		0.027	882.8607	454.0516	1336.9123	1428.9238
0.028	1.2256	0.6876	1.9132	2.0565		0.028	865.4569	485.5767	1351.0336	1452.1614
0.029	1.1916	0.7334	1.9250	2.0529		0.029	841.4770	517.8576	1359.3346	1449.6577
0.030	1.1489	0.7801	1.9290	2.0494		0.030	811.2993	550.8554	1362.1547	1447.1539
0.031	1.0981	0.8278	1.9258	2.0188		0.031	775.3996	584.5304	1359.9299	1425.5628

0.032	1.0399	0.8764	1.9163	1.9713		0.032	734.3441	618.8419	1353.1860	1392.0226
0.033	0.9754	0.9258	1.9012	1.9238		0.033	688.7802	653.7487	1342.5289	1358.4975
0.034	0.9055	0.9760	1.8815	1.8763		0.034	639.4267	689.2086	1328.6353	1324.9759
0.035	0.8314	1.0270	1.8583	1.8289		0.035	587.0617	725.1790	1312.2407	1291.4543
0.036	0.7541	1.0786	1.8327	1.7845		0.036	532.5111	761.6165	1294.1276	1260.1311
0.037	0.6750	1.1308	1.8057	1.7528		0.037	476.6352	798.4772	1275.1124	1237.7126
0.038	0.5952	1.1835	1.7787	1.7210		0.038	420.3152	835.7167	1256.0319	1215.2941
0.039	0.5161	1.2367	1.7528	1.6945		0.039	364.4393	873.2901	1237.7295	1196.5762
0.040	0.4388	1.2903	1.7292	1.6733		0.040	309.8887	911.1522	1221.0409	1181.5888
0.041	0.3647	1.3443	1.7090	1.6521		0.041	257.5238	949.2572	1206.7810	1166.6013
0.042	0.2948	1.3985	1.6933	1.6308		0.042	208.1702	987.5594	1195.7296	1151.6138
0.043	0.2303	1.4530	1.6832	1.6483		0.043	162.6064	1026.0126	1188.6189	1163.9303
0.044	0.1721	1.5076	1.6797	1.6697		0.044	121.5509	1064.5703	1186.1212	1179.0464
0.045	0.1213	1.5623	1.6836	1.6988		0.045	85.6511	1103.1863	1188.8374	1199.6026
0.046	0.0786	1.6170	1.6955	1.7527		0.046	55.4734	1141.8138	1197.2872	1237.6728
0.047	0.0446	1.6716	1.7162	1.8066		0.047	31.4935	1180.4065	1211.9000	1275.7302
0.048	0.0200	1.7262	1.7461	1.8605		0.048	14.0897	1218.9178	1233.0074	1313.7732
0.049	0.0050	1.7805	1.7855	1.9452		0.049	3.5364	1257.3012	1260.8376	1373.6249
0.050	0.0000	1.8346	1.8346	2.0068		0.050	0.0000	1295.5106	1295.5106	1417.0913
0.051	0.0000	1.8884	1.8884	2.0639		0.051	0.0000	1333.4999	1333.4999	1457.4511
0.052	0.0000	1.9418	1.9418	2.1617		0.052	0.0000	1371.2233	1371.2233	1526.5076
0.053	0.0000	1.9948	1.9948	2.2102		0.053	0.0000	1408.6354	1408.6354	1560.7110

0.054	0.0000	2.0473	2.0473	2.2586		0.054	0.0000	1445.6910	1445.6910	1594.9144
0.055	0.0000	2.0992	2.0992	2.3071		0.055	0.0000	1482.3457	1482.3457	1629.1178
0.056	0.0000	2.1505	2.1505	2.3590		0.056	0.0000	1518.5551	1518.5551	1665.8116
0.057	0.0000	2.2011	2.2011	2.4129		0.057	0.0000	1554.2756	1554.2756	1703.8761
0.058	0.0000	2.2509	2.2509	2.4620		0.058	0.0000	1589.4643	1589.4643	1738.5506
0.059	0.0000	2.2999	2.2999	2.5110		0.059	0.0000	1624.0787	1624.0787	1773.1686
0.060	0.0000	2.3481	2.3481	2.5649		0.060	0.0000	1658.0770	1658.0770	1811.2116
0.061	0.0000	2.3953	2.3953	2.6114		0.061	0.0000	1691.4184	1691.4184	1844.0495
0.062	0.0000	2.4415	2.4415	2.6436		0.062	0.0000	1724.0627	1724.0627	1866.7832
0.063	0.0000	2.4867	2.4867	2.6758		0.063	0.0000	1755.9705	1755.9705	1889.5170
0.064	0.0000	2.5308	2.5308	2.7056		0.064	0.0000	1787.1034	1787.1034	1910.5244
0.065	0.0000	2.5737	2.5737	2.7341		0.065	0.0000	1817.4239	1817.4239	1930.7082
0.066	0.0000	2.6155	2.6155	2.7628		0.066	0.0000	1846.8953	1846.8953	1950.9201
0.067	0.0000	2.6559	2.6559	2.7950		0.067	0.0000	1875.4824	1875.4824	1973.6538
0.068	0.0000	2.6951	2.6951	2.8272		0.068	0.0000	1903.1505	1903.1505	1996.3876
0.069	0.0000	2.7330	2.7330	2.8606		0.069	0.0000	1929.8663	1929.8663	2020.0041
0.070	0.0000	2.7694	2.7694	2.8964		0.070	0.0000	1955.5977	1955.5977	2045.2746
0.071	0.0000	2.8044	2.8044	2.9322		0.071	0.0000	1980.3136	1980.3136	2070.5451
0.072	0.0000	2.8379	2.8379	2.9655		0.072	0.0000	2003.9843	2003.9843	2094.0728
0.073	0.0000	2.8699	2.8699	2.9977		0.073	0.0000	2026.5813	2026.5813	2116.8028
0.074	0.0000	2.9004	2.9004	3.0299		0.074	0.0000	2048.0772	2048.0772	2139.5327
0.075	0.0000	2.9292	2.9292	3.0621		0.075	0.0000	2068.4463	2068.4463	2162.2579

0.076	0.0000	2.9564	2.9564	3.0942		0.076	0.0000	2087.6640	2087.6640	2184.9831
0.077	0.0000	2.9820	2.9820	3.1154		0.077	0.0000	2105.7070	2105.7070	2199.9363
0.078	0.0000	3.0058	3.0058	3.1169		0.078	0.0000	2122.5538	2122.5538	2201.0122
0.079	0.0000	3.0280	3.0280	3.1185		0.079	0.0000	2138.1839	2138.1839	2202.0881
0.080	0.0000	3.0483	3.0483	3.1200		0.080	0.0000	2152.5786	2152.5786	2203.1641
0.081	0.0000	3.0670	3.0670	3.1215		0.081	0.0000	2165.7205	2165.7205	2204.2400
0.082	0.0000	3.0838	3.0838	3.1230		0.082	0.0000	2177.5937	2177.5937	2205.3160
0.083	0.0000	3.0988	3.0988	3.1228		0.083	0.0000	2188.1840	2188.1840	2205.1876
0.084	0.0000	3.1119	3.1119	3.1080		0.084	0.0000	2197.4786	2197.4786	2194.6834
0.085	0.0000	3.1232	3.1232	3.0931		0.085	0.0000	2205.4663	2205.4663	2184.1793
0.086	0.0000	3.1327	3.1327	3.0782		0.086	0.0000	2212.1375	2212.1375	2173.6752
0.087	0.0000	3.1403	3.1403	3.0633		0.087	0.0000	2217.4841	2217.4841	2163.1711
0.088	0.0000	3.1459	3.1459	3.0458		0.088	0.0000	2221.4997	2221.4997	2150.8113
0.089	0.0000	3.1497	3.1497	3.0267		0.089	0.0000	2224.1795	2224.1795	2137.3190
0.090	0.0000	3.1516	3.1516	3.0076		0.090	0.0000	2225.5202	2225.5202	2123.8267
0.091	0.0000	3.1516	3.1516	2.9885		0.091	0.0000	2225.5202	2225.5202	2110.3343
0.092	0.0000	3.1497	3.1497	2.9700		0.092	0.0000	2224.1795	2224.1795	2097.2431
0.093	0.0000	3.1459	3.1459	2.9551		0.093	0.0000	2221.4997	2221.4997	2086.7435
0.094	0.0000	3.1403	3.1403	2.9402		0.094	0.0000	2217.4841	2217.4841	2076.2440
0.095	0.0000	3.1327	3.1327	2.9254		0.095	0.0000	2212.1375	2212.1375	2065.7444
0.096	0.0000	3.1232	3.1232	2.9105		0.096	0.0000	2205.4663	2205.4663	2055.2448
0.097	0.0000	3.1119	3.1119	2.8943		0.097	0.0000	2197.4786	2197.4786	2043.7714

0.098	0.0000	3.0988	3.0988	2.8773		0.098	0.0000	2188.1840	2188.1840	2031.7737
0.099	0.0000	3.0838	3.0838	2.8603		0.099	0.0000	2177.5937	2177.5937	2019.7759
0.100	0.0000	3.0670	3.0670	2.8433		0.100	0.0000	2165.7205	2165.7205	2007.7781
0.101	0.0000	3.0483	3.0483	2.8239		0.101	0.0000	2152.5786	2152.5786	1994.0603
0.102	0.0000	3.0280	3.0280	2.7921		0.102	0.0000	2138.1839	2138.1839	1971.6381
0.103	0.0000	3.0058	3.0058	2.7604		0.103	0.0000	2122.5538	2122.5538	1949.2159
0.104	0.0000	2.9820	2.9820	2.7286		0.104	0.0000	2105.7070	2105.7070	1926.7898
0.105	0.0000	2.9564	2.9564	2.6968		0.105	0.0000	2087.6640	2087.6640	1904.3593
0.106	0.0000	2.9292	2.9292	2.6651		0.106	0.0000	2068.4463	2068.4463	1881.9287
0.107	0.0000	2.9004	2.9004	2.6394		0.107	0.0000	2048.0772	2048.0772	1863.7769
0.108	0.0000	2.8699	2.8699	2.6155		0.108	0.0000	2026.5813	2026.5813	1846.9322
0.109	0.0000	2.8379	2.8379	2.5917		0.109	0.0000	2003.9843	2003.9843	1830.0874
0.110	0.0000	2.8044	2.8044	2.5690		0.110	0.0000	1980.3136	1980.3136	1814.0764
0.111	0.0000	2.7694	2.7694	2.5520		0.111	0.0000	1955.5977	1955.5977	1802.0786
0.112	0.0000	2.7330	2.7330	2.5350		0.112	0.0000	1929.8663	1929.8663	1790.0808
0.113	0.0000	2.6951	2.6951	2.5180		0.113	0.0000	1903.1505	1903.1505	1778.0831
0.114	0.0000	2.6559	2.6559	2.5010		0.114	0.0000	1875.4824	1875.4824	1766.0853
0.115	0.0000	2.6155	2.6155	2.4793		0.115	0.0000	1846.8953	1846.8953	1750.7544
0.116	0.0000	2.5737	2.5737	2.4554		0.116	0.0000	1817.4239	1817.4239	1733.9050
0.117	0.0000	2.5308	2.5308	2.4316		0.117	0.0000	1787.1034	1787.1034	1717.0556
0.118	0.0000	2.4867	2.4867	2.4070		0.118	0.0000	1755.9705	1755.9705	1699.6827
0.119	0.0000	2.4415	2.4415	2.3752		0.119	0.0000	1724.0627	1724.0627	1677.2641

0.120	0.0000	2.3953	2.3953	2.3435		0.120	0.0000	1691.4184	1691.4184	1654.8456
0.121	0.0000	2.3481	2.3481	2.3055		0.121	0.0000	1658.0770	1658.0770	1628.0525
0.122	0.0000	2.2999	2.2999	2.2581		0.122	0.0000	1624.0787	1624.0787	1594.5309
0.123	0.0000	2.2509	2.2509	2.2106		0.123	0.0000	1589.4643	1589.4643	1560.9984
0.124	0.0000	2.2011	2.2011	2.1631		0.124	0.0000	1554.2756	1554.2756	1527.4582
0.125	0.0000	2.1505	2.1505	2.1156		0.125	0.0000	1518.5551	1518.5551	1493.9326
0.126	0.0000	2.0992	2.0992	2.0681		0.126	0.0000	1482.3457	1482.3457	1460.4110
0.127	0.0000	2.0473	2.0473	2.0156		0.127	0.0000	1445.6910	1445.6910	1423.2943
0.128	0.0000	1.9948	1.9948	1.9629		0.128	0.0000	1408.6354	1408.6354	1386.0920
0.129	0.0000	1.9418	1.9418	1.9102		0.129	0.0000	1371.2233	1371.2233	1348.8852
0.130	0.0000	1.8884	1.8884	1.8389		0.130	0.0000	1333.4999	1333.4999	1298.5445
0.131	0.0000	1.8346	1.8346	1.7392		0.131	0.0000	1295.5106	1295.5106	1228.1449
0.132	0.0000	1.7805	1.7805	1.6701		0.132	0.0000	1257.3012	1257.3012	1179.3424
0.133	0.0000	1.7262	1.7262	1.6226		0.133	0.0000	1218.9178	1218.9178	1145.8208
0.134	0.0000	1.6716	1.6716	1.5337		0.134	0.0000	1180.4065	1180.4065	1083.0503
0.135	0.0000	1.6170	1.6170	1.4716		0.135	0.0000	1141.8138	1141.8138	1039.1492
0.136	0.0000	1.5623	1.5623	1.4185		0.136	0.0000	1103.1863	1103.1863	1001.6513
0.137	0.0000	1.5076	1.5076	1.3191		0.137	0.0000	1064.5703	1064.5703	931.4808
0.138	0.0000	1.4530	1.4530	1.2664		0.138	0.0000	1026.0126	1026.0126	894.2767
0.139	0.0000	1.3985	1.3985	1.2197		0.139	0.0000	987.5594	987.5594	861.2981
0.140	0.0000	1.3443	1.3443	1.1880		0.140	0.0000	949.2572	949.2572	838.8683
0.141	0.0000	1.2903	1.2903	1.1562		0.141	0.0000	911.1522	911.1522	816.4385

0.142	0.0000	1.2367	1.2367	1.1244		0.142	0.0000	873.2901	873.2901	794.0136
0.143	0.0000	1.1835	1.1835	1.0927		0.143	0.0000	835.7167	835.7167	771.5921
0.144	0.0000	1.1308	1.1308	1.0609		0.144	0.0000	798.4772	798.4772	749.1706
0.145	0.0000	1.0786	1.0786	1.0385		0.145	0.0000	761.6165	761.6165	733.3451
0.146	0.0000	1.0270	1.0270	1.0173		0.146	0.0000	725.1790	725.1790	718.3599
0.147	0.0000	0.9760	0.9760	0.9961		0.147	0.0000	689.2086	689.2086	703.3746
0.148	0.0000	0.9258	0.9258	0.9707		0.148	0.0000	653.7487	653.7487	685.4563
0.149	0.0000	0.8764	0.8764	0.9354		0.149	0.0000	618.8419	618.8419	660.5622
0.150	0.0000	0.8278	0.8278	0.9002		0.150	0.0000	584.5304	584.5304	635.6680
0.151	0.0000	0.7801	0.7801	0.8577		0.151	0.0000	550.8554	550.8554	605.6495
0.152	0.0000	0.7334	0.7334	0.8102		0.152	0.0000	517.8576	517.8576	572.1285
0.153	0.0000	0.6876	0.6876	0.7627		0.153	0.0000	485.5767	485.5767	538.5932
0.154	0.0000	0.6430	0.6430	0.7152		0.154	0.0000	454.0516	454.0516	505.0542
0.155	0.0000	0.5995	0.5995	0.6253		0.155	0.0000	423.3203	423.3203	441.5660
0.156	0.0000	0.5571	0.5571	0.5778		0.156	0.0000	393.4198	393.4198	408.0456
0.157	0.0000	0.5160	0.5160	0.5290		0.157	0.0000	364.3862	364.3862	373.5489
0.158	0.0000	0.4762	0.4762	0.4763		0.158	0.0000	336.2544	336.2544	336.3448
0.159	0.0000	0.4377	0.4377	0.4236		0.159	0.0000	309.0583	309.0583	299.1316
0.160	0.0000	0.4005	0.4005	0.3709		0.160	0.0000	282.8308	282.8308	261.9074
0.161	0.0000	0.3648	0.3648	0.3216		0.161	0.0000	257.6033	257.6033	227.0907
0.162	0.0000	0.3305	0.3305	0.2741		0.162	0.0000	233.4063	233.4063	193.5702
0.163	0.0000	0.2978	0.2978	0.2281		0.163	0.0000	210.2690	210.2690	161.0874

0.164	0.0000	0.2665	0.2665	0.1824		0.164	0.0000	188.2193	188.2193	128.7964
0.165	0.0000	0.2369	0.2369	0.1400		0.165	0.0000	167.2836	167.2836	98.8596
0.166	0.0000	0.2089	0.2089	0.1188		0.166	0.0000	147.4872	147.4872	83.8785
0.167	0.0000	0.1825	0.1825	0.1048		0.167	0.0000	128.8541	128.8541	73.9910
0.168	0.0000	0.1578	0.1578	0.1048		0.168	0.0000	111.4065	111.4065	73.9910
0.169	0.0000	0.1348	0.1348	0.1048		0.169	0.0000	95.1656	95.1656	73.9910
0.170	0.0000	0.1135	0.1135	0.1048		0.170	0.0000	80.1510	80.1510	73.9910
0.171	0.0000	0.0940	0.0940	0.1068		0.171	0.0000	66.3806	66.3806	75.4310
0.172	0.0000	0.0763	0.0763	0.1095		0.172	0.0000	53.8712	53.8712	77.3133
0.173	0.0000	0.0604	0.0604	0.1122		0.173	0.0000	42.6377	42.6377	79.1956
0.174	0.0000	0.0463	0.0463	0.1148		0.174	0.0000	32.6938	32.6938	81.0779
0.175	0.0000	0.0341	0.0341	0.1175		0.175	0.0000	24.0513	24.0513	82.9602
0.176	0.0000	0.0237	0.0237	0.1201		0.176	0.0000	16.7208	16.7208	84.8425
0.177	0.0000	0.0152	0.0152	0.1228		0.177	0.0000	10.7110	10.7110	86.7249
0.178	0.0000	0.0085	0.0085	0.1184		0.178	0.0000	6.0292	6.0292	83.5755
0.179	0.0000	0.0038	0.0038	0.1095		0.179	0.0000	2.6810	2.6810	77.3161
0.180	0.0000	0.0009	0.0009	0.1006		0.180	0.0000	0.6704	0.6704	71.0566
0.181	0.0000	0.0000	0.0000	0.0918		0.181	0.0000	0.0000	0.0000	64.7971

Supplementary Table 3

Figure Panel: 1E and 1F

Reference Publication: Weyand et al. (2010)

Reference Publication Figure: Figure 1A, Step #1

Speed (m/s): 5.0

Footwear Condition: Shod

Foot-Strike Type: Fore-Foot

Runner's Mass (kg): 69.21

Time (s)	Impulse 1 Force (W_b)	Impulse 2 Force (W_b)	Total Model Force (W_b)	Digitized Force (W_b)	Actual Data Force (W_b)		Time (s)	Impulse 1 Force (N)	Impulse 2 Force (N)	Total Model Force (N)	Digitized Force (N)	Actual Data Force (N)
0.000	0.0000	0.0000	0.0000	0.0000	0.0000		0.000	0.0000	0.0000	0.0000	0.0000	0.0000
0.001	0.0013	0.0010	0.0023	0.0904	0.0962		0.001	0.8927	0.6659	1.5586	61.3214	65.2260
0.002	0.0053	0.0039	0.0092	0.1053	0.1081		0.002	3.5654	2.6627	6.2281	71.3978	73.3180
0.003	0.0118	0.0088	0.0206	0.1201	0.1223		0.003	8.0015	5.9881	13.9896	81.4742	82.9550
0.004	0.0209	0.0157	0.0366	0.1350	0.1390		0.004	14.1737	10.6381	24.8118	91.5506	94.3030
0.005	0.0325	0.0245	0.0570	0.1498	0.1585		0.005	22.0439	16.6072	38.6511	101.6270	107.5240
0.006	0.0465	0.0352	0.0818	0.1729	0.1810		0.006	31.5637	23.8882	55.4519	117.2643	122.7720
0.007	0.0629	0.0479	0.1108	0.1993	0.2067		0.007	42.6743	32.4725	75.1468	135.1795	140.1900
0.008	0.0815	0.0624	0.1440	0.2257	0.2357		0.008	55.3073	42.3498	97.6571	153.0947	159.8900
0.009	0.1023	0.0789	0.1812	0.2521	0.2683		0.009	69.3847	53.5085	122.8931	171.0099	181.9900

0.010	0.1250	0.0972	0.2223	0.2830	0.3045		0.010	84.8197	65.9351	150.7548	191.9902	206.5500
0.011	0.1497	0.1174	0.2670	0.3158	0.3444		0.011	101.5172	79.6148	181.1321	214.2358	233.6400
0.012	0.1760	0.1394	0.3154	0.3486	0.3881		0.012	119.3743	94.5315	213.9058	236.4815	263.2800
0.013	0.2039	0.1632	0.3670	0.3887	0.4356		0.013	138.2809	110.6672	248.9480	263.6845	295.4900
0.014	0.2331	0.1887	0.4218	0.4366	0.4869		0.014	158.1203	128.0028	286.1231	296.1327	330.2400
0.015	0.2636	0.2160	0.4796	0.4844	0.5418		0.015	178.7703	146.5175	325.2878	328.5808	367.5100
0.016	0.2950	0.2450	0.5400	0.5323	0.6004		0.016	200.1035	166.1895	366.2930	361.0290	407.2400
0.017	0.3273	0.2757	0.6030	0.5801	0.6625		0.017	221.9885	186.9951	408.9836	393.4771	449.3500
0.018	0.3602	0.3080	0.6681	0.6408	0.7279		0.018	244.2903	208.9096	453.1999	434.6683	493.7500
0.019	0.3934	0.3419	0.7353	0.7109	0.7966		0.019	266.8714	231.9069	498.7783	482.2244	540.3200
0.020	0.4269	0.3774	0.8043	0.7810	0.8682		0.020	289.5926	255.9596	545.5521	529.7803	588.9100
0.021	0.4604	0.4143	0.8748	0.8511	0.9426		0.021	312.3137	281.0390	593.3527	577.3334	639.3800
0.022	0.4937	0.4528	0.9465	0.9288	1.0195		0.022	334.8948	307.1152	642.0100	630.0192	691.5400
0.023	0.5266	0.4926	1.0192	1.0181	1.0986		0.023	357.1966	334.1571	691.3537	690.5960	745.2000
0.024	0.5589	0.5339	1.0928	1.0727	1.1796		0.024	379.0816	362.1326	741.2142	727.5945	800.1500
0.025	0.5903	0.5765	1.1668	1.1113	1.2622		0.025	400.4149	391.0083	791.4231	753.8006	856.1800
0.026	0.6208	0.6203	1.2411	1.2432	1.3461		0.026	421.0648	420.7497	841.8146	843.2867	913.0300
0.027	0.6500	0.6654	1.3154	1.3001	1.4307		0.027	440.9043	451.3215	892.2258	881.8630	970.4700
0.028	0.6779	0.7116	1.3895	1.3638	1.5159		0.028	459.8108	482.6872	942.4980	925.0454	1028.2300
0.029	0.7042	0.7590	1.4632	1.4339	1.6012		0.029	477.6679	514.8093	992.4772	972.6022	1086.1000
0.030	0.7288	0.8074	1.5362	1.5201	1.6860		0.030	494.3654	547.6498	1042.0152	1031.0811	1143.6000
0.031	0.7516	0.8568	1.6084	1.6069	1.7702		0.031	509.8005	581.1693	1090.9698	1089.9517	1200.7000

0.032	0.7723	0.9072	1.6795	1.6770	1.8532		0.032	523.8779	615.3280	1139.2058	1137.5073	1257.0000
0.033	0.7910	0.9584	1.7494	1.7530	1.9344		0.033	536.5108	650.0851	1186.5959	1189.0565	1312.1000
0.034	0.8073	1.0105	1.8178	1.8360	2.0136		0.034	547.6214	685.3992	1233.0207	1245.3489	1365.8000
0.035	0.8214	1.0633	1.8847	1.9092	2.0901		0.035	557.1412	721.2283	1278.3695	1294.9957	1417.7000
0.036	0.8330	1.1168	1.9498	1.9793	2.1636		0.036	565.0115	757.5296	1322.5411	1342.5487	1467.6000
0.037	0.8421	1.1710	2.0130	2.0494	2.2338		0.037	571.1837	794.2600	1365.4436	1390.1042	1515.2000
0.038	0.8486	1.2257	2.0743	2.1168	2.3002		0.038	575.6198	831.3755	1406.9953	1435.8208	1560.2000
0.039	0.8526	1.2809	2.1335	2.1803	2.3624		0.039	578.2924	868.8320	1447.1244	1478.9205	1602.4000
0.040	0.8539	1.3366	2.1904	2.2488	2.4202		0.040	579.1851	906.5848	1485.7700	1525.3634	1641.6000
0.041	0.8526	1.3926	2.2451	2.3199	2.4731		0.041	578.2924	944.5890	1522.8814	1573.5868	1677.5000
0.042	0.8486	1.4489	2.2975	2.3949	2.5213		0.042	575.6198	982.7993	1558.4190	1624.4351	1710.2000
0.043	0.8421	1.5055	2.3476	2.4427	2.5646		0.043	571.1837	1021.1700	1592.3537	1656.8849	1739.6000
0.044	0.8330	1.5622	2.3952	2.4905	2.6031		0.044	565.0115	1059.6556	1624.6671	1689.3347	1765.7000
0.045	0.8214	1.6191	2.4404	2.5370	2.6369		0.045	557.1412	1098.2101	1655.3513	1720.8239	1788.6000
0.046	0.8073	1.6759	2.4833	2.5830	2.6661		0.046	547.6214	1136.7876	1684.4091	1752.0334	1808.4000
0.047	0.7910	1.7328	2.5237	2.6290	2.6911		0.047	536.5108	1175.3421	1711.8530	1783.2429	1825.4000
0.048	0.7723	1.7895	2.5619	2.6750	2.7125		0.048	523.8779	1213.8277	1737.7056	1814.4524	1839.9000
0.049	0.7516	1.8461	2.5977	2.7028	2.7307		0.049	509.8005	1252.1985	1761.9990	1833.2970	1852.2000
0.050	0.7288	1.9024	2.6312	2.7225	2.7461		0.050	494.3654	1290.4087	1784.7742	1846.6614	1862.7000
0.051	0.7042	1.9584	2.6627	2.7422	2.7595		0.051	477.6679	1328.4129	1806.0808	1860.0257	1871.8000
0.052	0.6779	2.0141	2.6920	2.7619	2.7713		0.052	459.8108	1366.1658	1825.9766	1873.3901	1879.8000
0.053	0.6500	2.0693	2.7193	2.7816	2.7824		0.053	440.9043	1403.6223	1844.5265	1886.7545	1887.3000

0.054	0.6208	2.1240	2.7448	2.7968	2.7930		0.054	421.0648	1440.7378	1861.8026	1897.0841	1894.5000
0.055	0.5903	2.1782	2.7685	2.8117	2.8039		0.055	400.4149	1477.4681	1877.8829	1907.1607	1901.9000
0.056	0.5589	2.2317	2.7906	2.8265	2.8154		0.056	379.0816	1513.7694	1892.8510	1917.2372	1909.7000
0.057	0.5266	2.2845	2.8111	2.8414	2.8278		0.057	357.1966	1549.5985	1906.7951	1927.3137	1918.1000
0.058	0.4937	2.3366	2.8303	2.8562	2.8417		0.058	334.8948	1584.9127	1919.8075	1937.3902	1927.5000
0.059	0.4604	2.3878	2.8483	2.8703	2.8568		0.059	312.3137	1619.6698	1931.9835	1946.9207	1937.8000
0.060	0.4269	2.4382	2.8651	2.8831	2.8737		0.060	289.5926	1653.8285	1943.4210	1955.5789	1949.2000
0.061	0.3934	2.4876	2.8811	2.8958	2.8919		0.061	266.8714	1687.3480	1954.2194	1964.2371	1961.6000
0.062	0.3602	2.5360	2.8962	2.9086	2.9117		0.062	244.2903	1720.1884	1964.4787	1972.8954	1975.0000
0.063	0.3273	2.5834	2.9107	2.9214	2.9328		0.063	221.9885	1752.3106	1974.2991	1981.5536	1989.3000
0.064	0.2950	2.6296	2.9246	2.9341	2.9547		0.064	200.1035	1783.6762	1983.7798	1990.2118	2004.2000
0.065	0.2636	2.6747	2.9383	2.9549	2.9774		0.065	178.7703	1814.2480	1993.0183	2004.3065	2019.6000
0.066	0.2331	2.7185	2.9517	2.9770	3.0004		0.066	158.1203	1843.9895	2002.1098	2019.3009	2035.2000
0.067	0.2039	2.7611	2.9650	2.9991	3.0236		0.067	138.2809	1872.8651	2011.1460	2034.2952	2050.9000
0.068	0.1760	2.8024	2.9784	3.0212	3.0463		0.068	119.3743	1900.8406	2020.2149	2049.2896	2066.3000
0.069	0.1497	2.8422	2.9919	3.0431	3.0683		0.069	101.5172	1927.8826	2029.3998	2064.1601	2081.2000
0.070	0.1250	2.8807	3.0057	3.0628	3.0893		0.070	84.8197	1953.9588	2038.7785	2077.5242	2095.5000
0.071	0.1023	2.9176	3.0199	3.0825	3.1089		0.071	69.3847	1979.0382	2048.4228	2090.8882	2108.8000
0.072	0.0815	2.9531	3.0346	3.1022	3.1269		0.072	55.3073	2003.0908	2058.3981	2104.2523	2121.0000
0.073	0.0629	2.9870	3.0499	3.1219	3.1433		0.073	42.6743	2026.0881	2068.7625	2117.6164	2132.1000
0.074	0.0465	3.0193	3.0659	3.1409	3.1576		0.074	31.5637	2048.0027	2079.5664	2130.4791	2141.8000
0.075	0.0325	3.0500	3.0825	3.1582	3.1700		0.075	22.0439	2068.8083	2090.8522	2142.2046	2150.2000

0.076	0.0209	3.0790	3.0999	3.1755	3.1803		0.076	14.1737	2088.4802	2102.6539	2153.9302	2157.2000
0.077	0.0118	3.1063	3.1181	3.1928	3.1886		0.077	8.0015	2106.9950	2114.9964	2165.6557	2162.8000
0.078	0.0053	3.1318	3.1371	3.2101	3.1950		0.078	3.5654	2124.3306	2127.8959	2177.3813	2167.2000
0.079	0.0013	3.1556	3.1569	3.2209	3.1998		0.079	0.8927	2140.4663	2141.3590	2184.7150	2170.4000
0.080	0.0000	3.1776	3.1776	3.2263	3.2030		0.080	0.0000	2155.3829	2155.3829	2188.4263	2172.6000
0.081	0.0000	3.1978	3.1978	3.2318	3.2048		0.081	0.0000	2169.0627	2169.0627	2192.1375	2173.8000
0.082	0.0000	3.2161	3.2161	3.2373	3.2054		0.082	0.0000	2181.4893	2181.4893	2195.8488	2174.2000
0.083	0.0000	3.2326	3.2326	3.2428	3.2049		0.083	0.0000	2192.6479	2192.6479	2199.5600	2173.9000
0.084	0.0000	3.2471	3.2471	3.2482	3.2034		0.084	0.0000	2202.5253	2202.5253	2203.2713	2172.9000
0.085	0.0000	3.2598	3.2598	3.2537	3.2011		0.085	0.0000	2211.1096	2211.1096	2206.9826	2171.3000
0.086	0.0000	3.2705	3.2705	3.2592	3.1978		0.086	0.0000	2218.3906	2218.3906	2210.6938	2169.1000
0.087	0.0000	3.2793	3.2793	3.2646	3.1939		0.087	0.0000	2224.3596	2224.3596	2214.4051	2166.4000
0.088	0.0000	3.2862	3.2862	3.2620	3.1891		0.088	0.0000	2229.0096	2229.0096	2212.5971	2163.2000
0.089	0.0000	3.2911	3.2911	3.2586	3.1834		0.089	0.0000	2232.3350	2232.3350	2210.3416	2159.3000
0.090	0.0000	3.2940	3.2940	3.2553	3.1766		0.090	0.0000	2234.3319	2234.3319	2208.0861	2154.7000
0.091	0.0000	3.2950	3.2950	3.2520	3.1688		0.091	0.0000	2234.9977	2234.9977	2205.8306	2149.4000
0.092	0.0000	3.2940	3.2940	3.2487	3.1597		0.092	0.0000	2234.3319	2234.3319	2203.5751	2143.2000
0.093	0.0000	3.2911	3.2911	3.2453	3.1492		0.093	0.0000	2232.3350	2232.3350	2201.3195	2136.1000
0.094	0.0000	3.2862	3.2862	3.2420	3.1373		0.094	0.0000	2229.0096	2229.0096	2199.0640	2128.0000
0.095	0.0000	3.2793	3.2793	3.2312	3.1237		0.095	0.0000	2224.3596	2224.3596	2191.7278	2118.8000
0.096	0.0000	3.2705	3.2705	3.2198	3.1085		0.096	0.0000	2218.3906	2218.3906	2184.0091	2108.5000
0.097	0.0000	3.2598	3.2598	3.2084	3.0916		0.097	0.0000	2211.1096	2211.1096	2176.2904	2097.0000

0.098	0.0000	3.2471	3.2471	3.1971	3.0730		0.098	0.0000	2202.5253	2202.5253	2168.5717	2084.4000
0.099	0.0000	3.2326	3.2326	3.1857	3.0525		0.099	0.0000	2192.6479	2192.6479	2160.8530	2070.5000
0.100	0.0000	3.2161	3.2161	3.1743	3.0305		0.100	0.0000	2181.4893	2181.4893	2153.1343	2055.6000
0.101	0.0000	3.1978	3.1978	3.1541	3.0069		0.101	0.0000	2169.0627	2169.0627	2139.3956	2039.6000
0.102	0.0000	3.1776	3.1776	3.1310	2.9820		0.102	0.0000	2155.3829	2155.3829	2123.7662	2022.7000
0.103	0.0000	3.1556	3.1556	3.1080	2.9558		0.103	0.0000	2140.4663	2140.4663	2108.1368	2004.9000
0.104	0.0000	3.1318	3.1318	3.0849	2.9286		0.104	0.0000	2124.3306	2124.3306	2092.5075	1986.5000
0.105	0.0000	3.1063	3.1063	3.0604	2.9006		0.105	0.0000	2106.9950	2106.9950	2075.8831	1967.5000
0.106	0.0000	3.0790	3.0790	3.0294	2.8719		0.106	0.0000	2088.4802	2088.4802	2054.8753	1948.0000
0.107	0.0000	3.0500	3.0500	2.9985	2.8428		0.107	0.0000	2068.8083	2068.8083	2033.8675	1928.3000
0.108	0.0000	3.0193	3.0193	2.9680	2.8135		0.108	0.0000	2048.0027	2048.0027	2013.2015	1908.4000
0.109	0.0000	2.9870	2.9870	2.9402	2.7842		0.109	0.0000	2026.0881	2026.0881	1994.3571	1888.5000
0.110	0.0000	2.9531	2.9531	2.9124	2.7547		0.110	0.0000	2003.0908	2003.0908	1975.5126	1868.5000
0.111	0.0000	2.9176	2.9176	2.8847	2.7253		0.111	0.0000	1979.0382	1979.0382	1956.6682	1848.6000
0.112	0.0000	2.8807	2.8807	2.8569	2.6962		0.112	0.0000	1953.9588	1953.9588	1937.8237	1828.8000
0.113	0.0000	2.8422	2.8422	2.8291	2.6671		0.113	0.0000	1927.8826	1927.8826	1918.9793	1809.1000
0.114	0.0000	2.8024	2.8024	2.8013	2.6381		0.114	0.0000	1900.8406	1900.8406	1900.1348	1789.4000
0.115	0.0000	2.7611	2.7611	2.7735	2.6089		0.115	0.0000	1872.8651	1872.8651	1881.2904	1769.6000
0.116	0.0000	2.7185	2.7185	2.7409	2.5797		0.116	0.0000	1843.9895	1843.9895	1859.1675	1749.8000
0.117	0.0000	2.6747	2.6747	2.7046	2.5501		0.117	0.0000	1814.2480	1814.2480	1834.5307	1729.7000
0.118	0.0000	2.6296	2.6296	2.6687	2.5201		0.118	0.0000	1783.6762	1783.6762	1810.1770	1709.4000
0.119	0.0000	2.5834	2.5834	2.6337	2.4895		0.119	0.0000	1752.3106	1752.3106	1786.4623	1688.6000

0.120	0.0000	2.5360	2.5360	2.5988	2.4582		0.120	0.0000	1720.1884	1720.1884	1762.7477	1667.4000
0.121	0.0000	2.4876	2.4876	2.5659	2.4259		0.121	0.0000	1687.3480	1687.3480	1740.4440	1645.5000
0.122	0.0000	2.4382	2.4382	2.5381	2.3926		0.122	0.0000	1653.8285	1653.8285	1721.5945	1622.9000
0.123	0.0000	2.3878	2.3878	2.5103	2.3581		0.123	0.0000	1619.6698	1619.6698	1702.7451	1599.5000
0.124	0.0000	2.3366	2.3366	2.4825	2.3224		0.124	0.0000	1584.9127	1584.9127	1683.8957	1575.3000
0.125	0.0000	2.2845	2.2845	2.4512	2.2856		0.125	0.0000	1549.5985	1549.5985	1662.6341	1550.3000
0.126	0.0000	2.2317	2.2317	2.4162	2.2472		0.126	0.0000	1513.7694	1513.7694	1638.9116	1524.3000
0.127	0.0000	2.1782	2.1782	2.3812	2.2077		0.127	0.0000	1477.4681	1477.4681	1615.1891	1497.5000
0.128	0.0000	2.1240	2.1240	2.3404	2.1669		0.128	0.0000	1440.7378	1440.7378	1587.5052	1469.8000
0.129	0.0000	2.0693	2.0693	2.2933	2.1247		0.129	0.0000	1403.6223	1403.6223	1555.5126	1441.2000
0.130	0.0000	2.0141	2.0141	2.2481	2.0814		0.130	0.0000	1366.1658	1366.1658	1524.8575	1411.8000
0.131	0.0000	1.9584	1.9584	2.2090	2.0370		0.131	0.0000	1328.4129	1328.4129	1498.3916	1381.7000
0.132	0.0000	1.9024	1.9024	2.1700	1.9914		0.132	0.0000	1290.4087	1290.4087	1471.9257	1350.8000
0.133	0.0000	1.8461	1.8461	2.1291	1.9450		0.133	0.0000	1252.1985	1252.1985	1444.1445	1319.3000
0.134	0.0000	1.7895	1.7895	2.0819	1.8977		0.134	0.0000	1213.8277	1213.8277	1412.1519	1287.2000
0.135	0.0000	1.7328	1.7328	2.0347	1.8495		0.135	0.0000	1175.3421	1175.3421	1380.1555	1254.5000
0.136	0.0000	1.6759	1.6759	1.9820	1.8007		0.136	0.0000	1136.7876	1136.7876	1344.4145	1221.4000
0.137	0.0000	1.6191	1.6191	1.9293	1.7513		0.137	0.0000	1098.2101	1098.2101	1308.6734	1187.9000
0.138	0.0000	1.5622	1.5622	1.8680	1.7015		0.138	0.0000	1059.6556	1059.6556	1267.0372	1154.1000
0.139	0.0000	1.5055	1.5055	1.8041	1.6512		0.139	0.0000	1021.1700	1021.1700	1223.6993	1120.0000
0.140	0.0000	1.4489	1.4489	1.7591	1.6008		0.140	0.0000	982.7993	982.7993	1193.1763	1085.8000
0.141	0.0000	1.3926	1.3926	1.7281	1.5502		0.141	0.0000	944.5890	944.5890	1172.1639	1051.5000

0.142	0.0000	1.3366	1.3366	1.6819	1.4995		0.142	0.0000	906.5848	906.5848	1140.8177	1017.1000
0.143	0.0000	1.2809	1.2809	1.6008	1.4488		0.143	0.0000	868.8320	868.8320	1085.8126	982.7500
0.144	0.0000	1.2257	1.2257	1.5441	1.3983		0.144	0.0000	831.3755	831.3755	1047.3360	948.4900
0.145	0.0000	1.1710	1.1710	1.4914	1.3480		0.145	0.0000	794.2600	794.2600	1011.5949	914.3600
0.146	0.0000	1.1168	1.1168	1.4422	1.2979		0.146	0.0000	757.5296	757.5296	978.2195	880.3900
0.147	0.0000	1.0633	1.0633	1.3950	1.2482		0.147	0.0000	721.2283	721.2283	946.2156	846.6300
0.148	0.0000	1.0105	1.0105	1.3453	1.1987		0.148	0.0000	685.3992	685.3992	912.5406	813.1000
0.149	0.0000	0.9584	0.9584	1.2919	1.1497		0.149	0.0000	650.0851	650.0851	876.3272	779.8400
0.150	0.0000	0.9072	0.9072	1.2386	1.1011		0.150	0.0000	615.3280	615.3280	840.1138	746.8600
0.151	0.0000	0.8568	0.8568	1.1852	1.0529		0.151	0.0000	581.1693	581.1693	803.9005	714.2000
0.152	0.0000	0.8074	0.8074	1.1318	1.0053		0.152	0.0000	547.6498	547.6498	767.6871	681.8700
0.153	0.0000	0.7590	0.7590	1.0784	0.9581		0.153	0.0000	514.8093	514.8093	731.4737	649.9000
0.154	0.0000	0.7116	0.7116	1.0253	0.9116		0.154	0.0000	482.6872	482.6872	695.4813	618.3100
0.155	0.0000	0.6654	0.6654	0.9726	0.8656		0.155	0.0000	451.3215	451.3215	659.7399	587.1400
0.156	0.0000	0.6203	0.6203	0.9213	0.8203		0.156	0.0000	420.7497	420.7497	624.9063	556.4000
0.157	0.0000	0.5765	0.5765	0.8741	0.7757		0.157	0.0000	391.0083	391.0083	592.9006	526.1300
0.158	0.0000	0.5339	0.5339	0.8269	0.7318		0.158	0.0000	362.1326	362.1326	560.8556	496.3600
0.159	0.0000	0.4926	0.4926	0.7714	0.6887		0.159	0.0000	334.1571	334.1571	523.2430	467.1200
0.160	0.0000	0.4528	0.4528	0.7203	0.6464		0.160	0.0000	307.1152	307.1152	488.5852	438.4400
0.161	0.0000	0.4143	0.4143	0.6731	0.6050		0.161	0.0000	281.0390	281.0390	456.5795	410.3700
0.162	0.0000	0.3774	0.3774	0.6283	0.5646		0.162	0.0000	255.9596	255.9596	426.1882	382.9500
0.163	0.0000	0.3419	0.3419	0.5893	0.5252		0.163	0.0000	231.9069	231.9069	399.7302	356.2400

0.164	0.0000	0.3080	0.3080	0.5503	0.4869		0.164	0.0000	208.9096	208.9096	373.2722	330.2800
0.165	0.0000	0.2757	0.2757	0.5125	0.4499		0.165	0.0000	186.9951	186.9951	347.5964	305.1500
0.166	0.0000	0.2450	0.2450	0.4775	0.4142		0.166	0.0000	166.1895	166.1895	323.8732	280.9200
0.167	0.0000	0.2160	0.2160	0.4425	0.3798		0.167	0.0000	146.5175	146.5175	300.1500	257.6500
0.168	0.0000	0.1887	0.1887	0.4075	0.3471		0.168	0.0000	128.0028	128.0028	276.4268	235.4200
0.169	0.0000	0.1632	0.1632	0.3726	0.3160		0.169	0.0000	110.6672	110.6672	252.7034	214.3100
0.170	0.0000	0.1394	0.1394	0.3376	0.2866		0.170	0.0000	94.5315	94.5315	228.9800	194.3700
0.171	0.0000	0.1174	0.1174	0.3044	0.2590		0.171	0.0000	79.6148	79.6148	206.4958	175.6800
0.172	0.0000	0.0972	0.0972	0.2766	0.2333		0.172	0.0000	65.9351	65.9351	187.6514	158.2600
0.173	0.0000	0.0789	0.0789	0.2489	0.2096		0.173	0.0000	53.5085	53.5085	168.8069	142.1600
0.174	0.0000	0.0624	0.0624	0.2211	0.1878		0.174	0.0000	42.3498	42.3498	149.9625	127.3840
0.175	0.0000	0.0479	0.0479	0.1979	0.1680		0.175	0.0000	32.4725	32.4725	134.2101	113.9230
0.176	0.0000	0.0352	0.0352	0.1800	0.1500		0.176	0.0000	23.8882	23.8882	122.1168	101.7560
0.177	0.0000	0.0245	0.0245	0.1622	0.1339		0.177	0.0000	16.6072	16.6072	110.0235	90.8410
0.178	0.0000	0.0157	0.0157	0.1444	0.1196		0.178	0.0000	10.6381	10.6381	97.9302	81.1200
0.179	0.0000	0.0088	0.0088	0.1265	0.1069		0.179	0.0000	5.9881	5.9881	85.8369	72.5240
0.180	0.0000	0.0039	0.0039	0.1147	0.0958		0.180	0.0000	2.6627	2.6627	77.8263	64.9740
0.181	0.0000	0.0010	0.0010	0.1039			0.181	0.0000	0.6659	0.6659	70.4803	
0.182	0.0000	0.0000	0.0000	0.0931			0.182	0.0000	0.0000	0.0000	63.1343	

Supplementary Table 4

Figure Panel: 1G and 1H

Reference Publication: Weyand et al. (2009)

Reference Publication Figure: Figure 1B, Step #1

Speed (m/s): 10.5

Footwear Condition: Shod

Foot-Strike Type: Fore-Foot

Runner's Mass (kg): 69.21

Time (s)	Impulse 1 Force (W_b)	Impulse 2 Force (W_b)	Total Model Force (W_b)	Digitized Force (W_b)	Actual Data Force (W_b)		Time (s)	Impulse 1 Force (N)	Impulse 2 Force (N)	Total Model Force (N)	Digitized Force (N)	Actual Data Force (N)
0.000	0.0000	0.0000	0.0000	0.0000	0.0000		0.000	0.0000	0.0000	0.0000	0.0000	0.0000
0.001	0.0086	0.0045	0.0131	0.0890	0.1112		0.001	5.8420	3.0617	8.9037	60.3453	75.4521
0.002	0.0343	0.0180	0.0523	0.1025	0.1470		0.002	23.2758	12.2322	35.5080	69.4969	99.7359
0.003	0.0767	0.0405	0.1172	0.1159	0.1925		0.003	52.0265	27.4677	79.4942	78.6485	130.5822
0.004	0.1351	0.0718	0.2069	0.1701	0.2493		0.004	91.6406	48.6958	140.3364	115.3719	169.1049
0.005	0.2086	0.1118	0.3204	0.2293	0.3191		0.005	141.4935	75.8152	217.3087	155.5274	216.4150
0.006	0.2960	0.1602	0.4563	0.2885	0.4033		0.006	200.7989	108.6966	309.4956	195.6830	273.5821
0.007	0.3960	0.2170	0.6130	0.3477	0.5036		0.007	268.6216	147.1835	415.8051	235.8385	341.5926
0.008	0.5070	0.2817	0.7887	0.4456	0.6211		0.008	343.8919	191.0923	534.9842	302.2210	421.3016
0.009	0.6272	0.3541	0.9813	0.5442	0.7569		0.009	425.4227	240.2139	665.6366	369.1250	513.3836

0.010	0.7547	0.4339	1.1886	0.6525	0.9115		0.010	511.9284	294.3141	806.2425	442.5691	618.2888
0.011	0.8876	0.5206	1.4082	0.9366	1.0854		0.011	602.0446	353.1352	955.1798	635.3054	736.1929
0.012	1.0237	0.6139	1.6375	1.0698	1.2781		0.012	694.3501	416.3968	1110.7469	725.6154	866.9624
0.013	1.1608	0.7132	1.8741	1.2220	1.4892		0.013	787.3893	483.7975	1271.1868	828.8676	1010.1176
0.014	1.2969	0.8182	2.1152	1.5178	1.7173		0.014	879.6949	555.0160	1434.7108	1029.5126	1164.8242
0.015	1.4298	0.9284	2.3581	1.8136	1.9606		0.015	969.8110	629.7130	1599.5240	1230.1625	1329.8411
0.016	1.5573	1.0431	2.6004	2.1094	2.2167		0.016	1056.3167	707.5325	1763.8492	1430.8079	1503.5673
0.017	1.6775	1.1619	2.8394	2.3744	2.4828		0.017	1137.8476	788.1037	1925.9512	1610.5439	1684.0493
0.018	1.7885	1.2842	3.0726	2.5223	2.7554		0.018	1213.1178	871.0426	2084.1604	1710.8833	1868.9878
0.019	1.8885	1.4093	3.2978	2.7078	3.0308		0.019	1280.9405	955.9539	2236.8944	1836.7102	2055.8052
0.020	1.9759	1.5368	3.5127	3.0036	3.3049		0.020	1340.2459	1042.4331	2382.6790	2037.3562	2241.7340
0.021	2.0494	1.6660	3.7154	3.2994	3.5734		0.021	1390.0988	1130.0680	2520.1668	2238.0051	2423.8169
0.022	2.1078	1.7963	3.9041	3.5475	3.8318		0.022	1429.7130	1218.4410	2648.1539	2406.3009	2599.0828
0.023	2.1502	1.9271	4.0772	3.6955	4.0757		0.023	1458.4636	1307.1309	2765.5945	2506.6403	2764.5541
0.024	2.1759	2.0577	4.2335	3.8978	4.3011		0.024	1475.8974	1395.7151	2871.6126	2643.9044	2917.4090
0.025	2.1845	2.1875	4.3720	4.1936	4.5040		0.025	1481.7394	1483.7715	2965.5110	2844.5527	3055.0632
0.026	2.1759	2.3159	4.4918	4.4222	4.6812		0.026	1475.8974	1570.8805	3046.7779	2999.5513	3175.2376
0.027	2.1502	2.4423	4.5925	4.5553	4.8298		0.027	1458.4636	1656.6268	3115.0905	3089.8606	3276.0533
0.028	2.1078	2.5661	4.6739	4.6952	4.9478		0.028	1429.7130	1740.6020	3170.3149	3184.7767	3356.1199
0.029	2.0494	2.6867	4.7361	4.8432	5.0340		0.029	1390.0988	1822.4058	3212.5046	3285.1161	3414.5622
0.030	1.9759	2.8036	4.7794	4.9276	5.0879		0.030	1340.2459	1901.6483	3241.8942	3342.4071	3451.0887
0.031	1.8885	2.9160	4.8045	4.9499	5.1098		0.031	1280.9405	1977.9521	3258.8926	3357.4852	3465.9502

0.032	1.7885	3.0237	4.8121	4.9721	5.1010		0.032	1213.1178	2050.9533	3264.0712	3372.5634	3459.9812
0.033	1.6775	3.1259	4.8034	4.9943	5.0635		0.033	1137.8476	2120.3042	3258.1518	3387.6415	3434.5721
0.034	1.5573	3.2223	4.7796	4.9637	5.0001		0.034	1056.3167	2185.6743	3241.9910	3366.8449	3391.5407
0.035	1.4298	3.3123	4.7421	4.8972	4.9140		0.035	969.8110	2246.7520	3216.5631	3321.7406	3333.1459
0.036	1.2969	3.3956	4.6925	4.8307	4.8090		0.036	879.6949	2303.2464	3182.9412	3276.6363	3261.9515
0.037	1.1608	3.4718	4.6326	4.7642	4.6893		0.037	787.3893	2354.8880	3142.2773	3231.5320	3180.7251
0.038	1.0237	3.5404	4.5640	4.6418	4.5590		0.038	694.3501	2401.4310	3095.7811	3148.5075	3092.3561
0.039	0.8876	3.6011	4.4887	4.4939	4.4224		0.039	602.0446	2442.6534	3044.6980	3048.2306	2999.7071
0.040	0.7547	3.6538	4.4085	4.3461	4.2836		0.040	511.9284	2478.3588	2990.2872	2947.9562	2905.5387
0.041	0.6272	3.6980	4.3252	4.1983	4.1462		0.041	425.4227	2508.3771	2933.7999	2847.6828	2812.3607
0.042	0.5070	3.7337	4.2407	4.0965	4.0136		0.042	343.8919	2532.5652	2876.4571	2778.6449	2722.4249
0.043	0.3960	3.7606	4.1566	4.0078	3.8885		0.043	268.6216	2550.8079	2819.4295	2718.4943	2637.5696
0.044	0.2960	3.7786	4.0746	3.9191	3.7730		0.044	200.7989	2563.0182	2763.8172	2658.3436	2559.2259
0.045	0.2086	3.7876	3.9962	3.8221	3.6685		0.045	141.4935	2569.1380	2710.6315	2592.5280	2488.3639
0.046	0.1351	3.7876	3.9227	3.7236	3.5759		0.046	91.6406	2569.1380	2660.7786	2525.6883	2425.4991
0.047	0.0767	3.7786	3.8553	3.6250	3.4951		0.047	52.0265	2563.0182	2615.0447	2458.8486	2370.6924
0.048	0.0343	3.7606	3.7949	3.5355	3.4256		0.048	23.2758	2550.8079	2574.0837	2398.1314	2323.6116
0.049	0.0086	3.7337	3.7423	3.4468	3.3666		0.049	5.8420	2532.5652	2538.4072	2337.9807	2283.5512
0.050	0.0000	3.6980	3.6980	3.3581	3.3164		0.050	0.0000	2508.3771	2508.3771	2277.8301	2249.5413
0.051	0.0000	3.6538	3.6538	3.3131	3.2734		0.051	0.0000	2478.3588	2478.3588	2247.2793	2220.3676
0.052	0.0000	3.6011	3.6011	3.2688	3.2356		0.052	0.0000	2442.6534	2442.6534	2217.2190	2194.7143
0.053	0.0000	3.5404	3.5404	3.2245	3.2010		0.053	0.0000	2401.4310	2401.4310	2187.1587	2171.2180

0.054	0.0000	3.4718	3.4718	3.1802	3.1675		0.054	0.0000	2354.8880	2354.8880	2157.0984	2148.5153
0.055	0.0000	3.3956	3.3956	3.1358	3.1334		0.055	0.0000	2303.2464	2303.2464	2127.0382	2125.3649
0.056	0.0000	3.3123	3.3123	3.0912	3.0970		0.056	0.0000	2246.7520	2246.7520	2096.7362	2100.6748
0.057	0.0000	3.2223	3.2223	3.0439	3.0569		0.057	0.0000	2185.6743	2185.6743	2064.6704	2073.5224
0.058	0.0000	3.1259	3.1259	2.9966	3.0123		0.058	0.0000	2120.3042	2120.3042	2032.6045	2043.2092
0.059	0.0000	3.0237	3.0237	2.9493	2.9622		0.059	0.0000	2050.9533	2050.9533	2000.5387	2009.2738
0.060	0.0000	2.9160	2.9160	2.9021	2.9065		0.060	0.0000	1977.9521	1977.9521	1968.4728	1971.4654
0.061	0.0000	2.8036	2.8036	2.8503	2.8449		0.061	0.0000	1901.6483	1901.6483	1933.3494	1929.7228
0.062	0.0000	2.6867	2.6867	2.7838	2.7778		0.062	0.0000	1822.4058	1822.4058	1888.2451	1884.1750
0.063	0.0000	2.5661	2.5661	2.7173	2.7054		0.063	0.0000	1740.6020	1740.6020	1843.1408	1835.0525
0.064	0.0000	2.4423	2.4423	2.6508	2.6282		0.064	0.0000	1656.6268	1656.6268	1798.0365	1782.6945
0.065	0.0000	2.3159	2.3159	2.5739	2.5468		0.065	0.0000	1570.8805	1570.8805	1745.8537	1727.4944
0.066	0.0000	2.1875	2.1875	2.4753	2.4618		0.066	0.0000	1483.7715	1483.7715	1679.0163	1669.8322
0.067	0.0000	2.0577	2.0577	2.3768	2.3737		0.067	0.0000	1395.7151	1395.7151	1612.1788	1610.0671
0.068	0.0000	1.9271	1.9271	2.2821	2.2829		0.068	0.0000	1307.1309	1307.1309	1547.9712	1548.4911
0.069	0.0000	1.7963	1.7963	2.1934	2.1898		0.069	0.0000	1218.4410	1218.4410	1487.8082	1485.3413
0.070	0.0000	1.6660	1.6660	2.1047	2.0946		0.070	0.0000	1130.0680	1130.0680	1427.6452	1420.7672
0.071	0.0000	1.5368	1.5368	2.0115	1.9974		0.071	0.0000	1042.4331	1042.4331	1364.3951	1354.8500
0.072	0.0000	1.4093	1.4093	1.9130	1.8983		0.072	0.0000	955.9539	955.9539	1297.5646	1287.6169
0.073	0.0000	1.2842	1.2842	1.8144	1.7972		0.073	0.0000	871.0426	871.0426	1230.7340	1219.0204
0.074	0.0000	1.1619	1.1619	1.7211	1.6940		0.074	0.0000	788.1037	788.1037	1167.4548	1149.0605
0.075	0.0000	1.0431	1.0431	1.6325	1.5888		0.075	0.0000	707.5325	707.5325	1107.3123	1077.6763

0.076	0.0000	0.9284	0.9284	1.5438	1.4815		0.076	0.0000	629.7130	629.7130	1047.1699	1004.9286
0.077	0.0000	0.8182	0.8182	1.4492	1.3724		0.077	0.0000	555.0160	555.0160	983.0076	930.9057
0.078	0.0000	0.7132	0.7132	1.3507	1.2617		0.078	0.0000	483.7975	483.7975	916.1542	855.7975
0.079	0.0000	0.6139	0.6139	1.2521	1.1498		0.079	0.0000	416.3968	416.3968	849.3008	779.9229
0.080	0.0000	0.5206	0.5206	1.1207	1.0375		0.080	0.0000	353.1352	353.1352	760.1426	703.7023
0.081	0.0000	0.4339	0.4339	0.9729	0.9254		0.081	0.0000	294.3141	294.3141	659.8989	627.6785
0.082	0.0000	0.3541	0.3541	0.8672	0.8145		0.082	0.0000	240.2139	240.2139	588.2321	552.4876
0.083	0.0000	0.2817	0.2817	0.7785	0.7060		0.083	0.0000	191.0923	191.0923	528.0682	478.8561
0.084	0.0000	0.2170	0.2170	0.6898	0.6009		0.084	0.0000	147.1835	147.1835	467.9043	407.5613
0.085	0.0000	0.1602	0.1602	0.5934	0.5004		0.085	0.0000	108.6966	108.6966	402.5276	339.4016
0.086	0.0000	0.1118	0.1118	0.4949	0.4057		0.086	0.0000	75.8152	75.8152	335.6977	275.1565
0.087	0.0000	0.0718	0.0718	0.3964	0.3178		0.087	0.0000	48.6958	48.6958	268.8678	215.5529
0.088	0.0000	0.0405	0.0405	0.3213	0.2377		0.088	0.0000	27.4677	27.4677	217.9458	161.2224
0.089	0.0000	0.0180	0.0180	0.2504	0.1661		0.089	0.0000	12.2322	12.2322	169.8311	112.6765
0.090	0.0000	0.0045	0.0045	0.1794	0.1036		0.090	0.0000	3.0617	3.0617	121.7163	70.2726
0.091	0.0000	0.0000	0.0000	0.1085			0.091	0.0000	0.0000	0.0000	73.6016	