DOES THE BODY MASS INFLUENCE THE WINNING TIME IN SKELETON AND LUGE COMPETITIONS?

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Introduction: The terminal speed in gravity powered sports disciplines is related to the square root of the ratio of weight to drag area [1], i.e. the greater the total gliding mass *TM* (athlete, gear, equipment, additional ballast) and the smaller the drag area, the faster is the speed. According to the skeleton rules [2], the total *TM* is restricted to 115 kg for men and 92 kg for women, including ballast masses attached to the sled. The luge rules [3] are more complex, but, in contrast to the skeleton rules, lighter athletes are disadvantaged. The aim of this study is to investigate the relationship between the athlete's body mass *BM* and the glide times in skeleton and luge competitions. In a perfectly fair scenario, the *BM* should not have any influence on the finish time.

Methods: I used the finish times of 6 training and 4 final runs of women's and men's luge and skeleton competitions at the 2018 PyeongChang Winter Olympics for correlating the two best finish times of each athlete with the athletes' *BM*. The required data were publicly available. Although the relationship of finish time and *BM* is inherently non-linear (equation 19 of [4], if the time *t* is the dependent variable, the mass is the independent one, and other variables including the glide distance *x* are constants), the actual fit curve of the data is almost linear, so that a linear regression is justified. The regressions were tested as to the fit equation (informing of the improvement of the finish time per unit mass), R^2-value (informing of the influence of *BM* on the finish time) and its p-value.

Results and Discussion: The data regressions of the 4 Olympic events are shown in Fig. 1, and the statistical data are listed in Table 1. The trends of all regressions were significant ($p \leq 0.044$), suggesting a shorter finish time as the *BM* increases. The influence of *BM* on the finish time ranged from 5% to 28%. The unexplained influence is due to the equipment + ballast mass and the skill of the athlete. From the gradient of the regression function, increasing the mass by 1 kg saves time of 22-72 ms. The practical application thereof results from the time difference between gold and silver medallist of the men's luge competition: 26 ms over four final runs, or 6.5 ms for one run on average. Although this competition showed the lowest time-saving gradient (21.6 ms/kg), saving 6.5 ms requires merely a ballast mass of 0.3 kg under identical conditions. This study provides evidence that despite

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ballast mass allowance during competitions, lighter athletes are disadvantaged and/or do not make good use of ballast within the regulations.

Table 1: Statistical data of the regressions shown in Fig. 1

	Skeleton men	Skeleton women	Luge men	Luge women
R^2	0.0764	0.2824	0.0510	0.1325
p (α = 0.1)	0.0325	0.0004	0.0440	0.0042
influence %	7.64%	28.24%	5.10%	13.25%
gradient (s/kg)	-0.0381	-0.0713	-0.0216	-0.0253

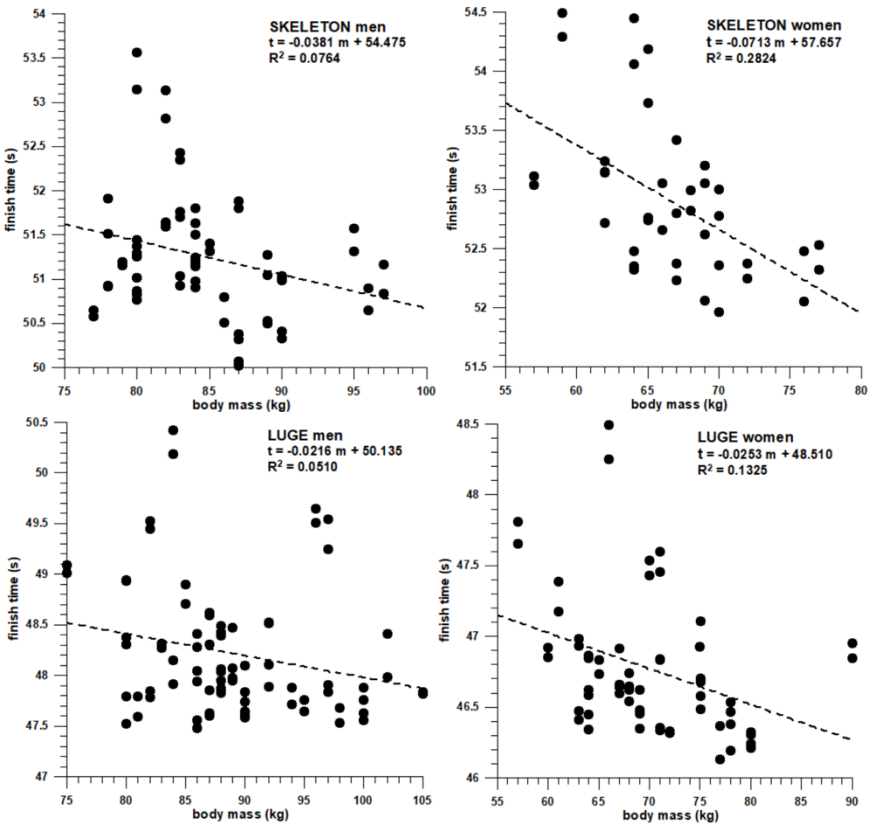

Fig. 1: Finish times vs athlete body mass in 4 competitions

1. Luethi S M, Denoth J (1987). The influence of aerodynamic and anthropometric factors on speed in skiing. Intl J Sport Biomech 3:345-352.
2. IBSF (2015) International Skeleton Rules. Lausanne, Switzerland
3. FIL (2014) International Luge Regulations. Salzburg Austria.
4. Fuss FK (2018) Slipstreaming in Gravity Powered Sports: Application to Racing Strategy in Ski Cross. Front Physiol 9:1032.

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