Investigating Duty Factor to Optimise Loaded Sprinting Performance in Military Service Members

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Summary

Duty factor (DF), defined as the ratio of stance over stride time, can be used as an indicator of performance and energy consumption during gait. Notably, the effect of speed and technique on DF has been quantified in unloaded civilian runners, but the effect of military load carriage on DF has yet to be investigated. Consequently, we analysed the DF of Canadian service members performing running sprints under three loading conditions to determine how DF changes with the load carried. A significant increase in DF was observed with increasing weight while running.

Introduction

Load carriage, while an essential component of a military service member's duties, alters running biomechanics [1]. Optimising running performance can decrease energy costs and injury risk [1] while increasing survivability [2]. Notably, in unloaded civilian runners, velocity is negatively correlated with duty factor (DF; the ratio of stance over stride time) and vertical centre of mass displacement [3]. The relationship between these biomechanical parameters indicates the presence of underlying movement strategies to optimise running performance. However, optimal spatiotemporal and kinematic characteristics of service members running while wearing heavy operational equipment have seldom been investigated. Gaining insights into the relationship between load and running biomechanics can help reveal strategies service members employ to optimise performance. Therefore, our study aimed to investigate how DF changes with increasing external load in service members. We hypothesised that DF would significantly increase with increasing external load [1].

Methods

Eighteen service members (14 male) performed three repetitions of a 10-metre sprint under three loading conditions: Slick (5.5 kg; boots, helmet, firearm), full-fighting order (FFO; 22 kg; Slick + loaded fragmentation and tactical vest), and backpack (BP; 38 kg; FFO + 16 kg BP). Movements were recorded using a 17-sensor inertial measurement unit suit (Xsens MVN Link, Movella, US) from which foot contact data were extracted. For each trial, the DF was calculated for one stride of the left foot in the middle of the trial. An ANOVA and post hoc analysis with Bonferroni correction assessed changes in DF across loading conditions.

Results and Discussion

DF was significantly different across the loading conditions ($p < 0.0001$). Post hoc analyses revealed statistical differences between all load conditions: BP and FFO ($p = 0.0053$), BP and Slick ($p < 0.0001$), and Slick and FFO ($p < 0.0001$; Figure 1).

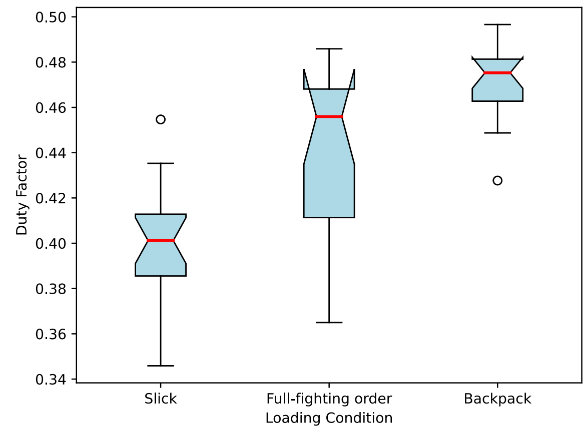

Figure 1: Notched boxplot of duty factor when sprinting under three loading conditions

The increasing DF between loading conditions indicates that, while sprinting, service members increase the proportion of time spent in the stance phase when carrying heavier loads. We hypothesise that service members increase their stance phase and decrease the flight phase to minimise the energetic costs related to the vertical centre of mass displacement.

Conclusions

Establishing the relationship between external loading and DF provides initial insight into natural performance optimisation strategies employed by military service members. Further work is dedicated to investigating the kinematic and vertical centre of mass displacement changes when running under load to better understand the relationship between external load and running biomechanics. By understanding this relationship, we can better comprehend the underlying phenomenon to more accurately model running at increasing loads. This information will allow us to decrease soldier susceptibility to injury while concurrently enhancing performance.

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