Analysis of Gait in Single- and Dual-Task Conditions in Soldiers before and after 13-KM Weighted March

Isaiah McNeilly[1], Amy Silder[2], Victoria Bode[3], Seth Elkin-Frankston[3], Gregory Freisinger[1]
[1]Mechanical and Aerospace Engineering Department, United States Miliary Academy, West Point, New York, USA
[2]Warfighter Performance Department, Naval Health Research Center, San Diego, California, USA
[3]Combat Capabilities Development Command Soldier Center, Natick, Massachusetts, USA
Email: gregory.freisinger@westpoint.edu

Summary

An increased understanding of the impact of cognitive loading alongside physical stressors on gait metrics may allow for the evaluation of military readiness. Our research aims to investigate whether there are changes in linear metrics of gait following an exposure to prolonged physical activity and if those changes are influenced by a cognitively demanding task. We hypothesized that there would be significant differences in speed, step length, step width, and stance time when comparing individuals before and after exposure to physical activity. Significant differences were found for speed, step length, and stance time following prolonged physical activity and when auditory cognitive load was applied. These results may allow for quantification of physical and cognitive readiness utilizing sensors in military environments.

Introduction

External factors such as the environment, fatigue, and cognitive demands can significantly affect walking mechanics [1,2]. Soldiers often carry significant loads over extended periods and distances, prior to high intensity military actions. Identifying the impact of physical exertion and cognitive loading on gait may provide an opportunity to quantify degradation in performance in real time.

Methods

The study consisted of 56 male U.S. Army Soldiers (22 ± 3 yr, 185.4 ± 28.1 lbs) who were required to travel 13-km on hard surface road with loaded rucks (87.6 ± 10.1 lbs) to begin a 72-hr simulated field mission. Spatiotemporal gait assessments were conducted before and after weighted march using a 6-m pressure-instrumented walkway [Zeno™ Walkway, ProtoKinetics, Havertown PA]. Participants were instructed to proceed down and back along the walkway. An auditory Stroop test was included as dual task condition. Speed, step width, step length, and stance time were computed for each trial. No completion time was specified for the weighted march; however, they were required to stay together in their approximate nine person squads (187 ± 22.3 min).

Results and Discussion

Table 1 presents the linear gait metrics calculated before (PRE) and after (POST) weighted march, as well as under single-(ST) and dual-task (DT) conditions. Statistically significant changes, utilizing paired t-tests (p-value < 0.05), are identified in bold in Table 1. These results align with existing research on fatigue-induced gait alterations, where a decrease in speed and step length often reflects a trade-off in performance due to reduced energy or motor control [2]. The increase in stance time may indicate a compensatory strategy, allowing for better stability or control in response to prolonged physical activity. Importantly, the DT conditions did demonstrate significant differences, both before and after the prolonged physical activity, potentially providing avenues to quantify this alteration to estimate readiness prior to military missions.

Conclusion

The observed changes in speed, step length, and stance time due to physical and cognitive loading, provide evidence that soldiers' gait is impacted by both physical exertion and cognitive load in military environments.

Disclaimer

I am a military service member or an employee of the U.S. Government. This work was prepared as part of my official duties. Title 17, U.S.C. §105, provides that copyright protection under this title is not available for any work of the U.S. Government. Title 17, U.S.C. §101, defines a U.S. Government work as work prepared by a military service member or employee of the U.S. Government as part of that person's official duties. This work was supported by the Combat Capabilities Development Command (DEVCOM) Soldier Center under the Measuring and Advancing Soldier Tactical Readiness and Effectiveness (MASTR-E) program.

References

[1] Nagano et al. (2014) *J Neuroeng Rehabil*, **11**:155

[2] Granacher et al. (2010) *J Neuroeng Rehabil,* **7**:56

Table 1: Gait metrics before and after (PRE vs POST) 13-km weighted march, with single- and dual-task (ST vs DT) condition

					P Value			
	PRE_ST (n = 56)	POST_ST (n=56)	PRE_DT (n=56)	POST_DT (n=56)	PRE_ST-POST_ST	PRE_DT-POST_DT	PRE_ST-PRE_DT	POST_ST-POST_DT
Speed, cm/s	118 ± 14.0	113 ± 14.3	108 ± 15.6	105 ± 13.9	**0.004**	**< 0.001**	**< 0.001**	**< 0.001**
Step Width, cm	14.0 ± 2.4	14.3 ± 2.8	14.3 ± 2.5	14.4 ± 2.6	0.110	0.310	0.055	0.169
Step Length, cm	68.9 ± 4.6	66.4 ± 5.1	64.3 ± 5.1	62.9 ± 5.4	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**
Stance Time, s	0.76 ± 0.05	0.78 ± 0.06	0.8 ± 0.08	0.8 ± 0.06	**0.004**	0.375	**< 0.001**	**< 0.001**

[a]Values presented as mean ± standard deviation.

Approved For Public Release PR2025-1986