

ENERGETICS AND BIOMECHANICS OF WALKER ASSISTED GAIT

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INTRODUCTION

Nearly 4 million Americans use a “walker” to aid with ambulation. Four-wheeled (4W) and two-wheeled (2W) walkers are pushed from behind and involve a normal bipedal (BP) walking pattern. In contrast, a four-footed (4F) walker must be lifted completely off the ground and requires a special type of walking pattern (gait) referred to as “step-to” (ST). ST walking requires the user to step forward with one foot and then step-to the same position with the other foot.

Previous research report that using a 4F walker increases energetic cost by 212%, but did not offer any biomechanical explanation for the elevated cost (Holder et al., 1993; Foley et al., 1996).

The purpose of this study was to investigate the energetic cost and kinematics of walking unassisted and with three different walkers. We tested two hypotheses: 1) At a fixed speed, walking with a 4F walker, using a ST gait is metabolically more expensive than walking unassisted or with a 2W or 4W walker. 2) The greater cost of using a 4F walker is due to the slower walking speed, cost of lifting the walker, and a disabled inverted-pendulum energy exchange mechanism associated with the step-to gait.

METHODS

Ten (5M, 5F) young, healthy, adult subjects volunteered. We trained the subjects to walk with the three walkers and the ST gait. After training, we measured preferred

walking speed (PWS) with each device and unassisted.

The experimental protocol consisted of eight trials: 1. standing, 2. BP at 1.25 m/s, 3. BP at 0.30 m/s, 4. 2W walker BP at 0.30 m/s, 5. 4W walker BP at 0.30 m/s, 6. 4F walker ST at 0.30 m/s, 7. ST unassisted at 0.30 m/s, 8. repeated lifting of 4F walker.

We measured metabolic rate using expired gas analysis. Net metabolic rate = exercise - standing. For the ST trial without walker, subjects matched their step-step-pause pattern to the rhythm used with the 4F walker. The 4F walker lifting trial consisted of lifting the walker forward, with a pause and then backward followed by another pause, matched to the same timing as the 4F walker trial.

We used repeated-measures ANOVA and Tukey post-hoc test with a criterion of $p < 0.05$.

RESULTS AND DISCUSSION

The net metabolic cost for subjects walking with the 4F walker at 0.30m/s was “only” 84% greater than bipedal (BP) walking at the same speed ($p < .001$). Metabolic cost with the 4W and 2W walkers was just 3% and 10% greater than BP walking at the same speed; respectively ($p < .001$; Figure 1).

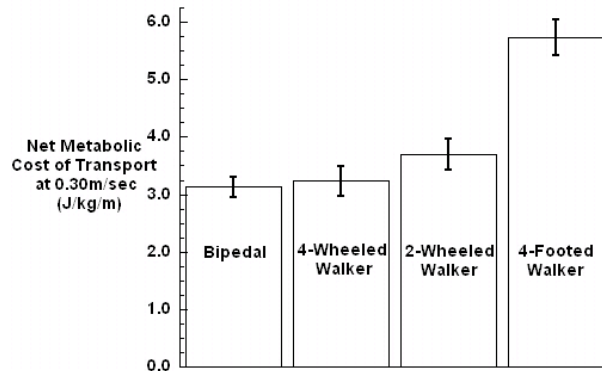


Figure 1: Mean values \pm SEM.

Net metabolic power for walking at 0.30 m/s with the 4F walker was not statistically different from the combined metabolic rates for ST walking at 0.30 m/s plus the cost of 4F walker lifting ($p=.25$, Figure 2).

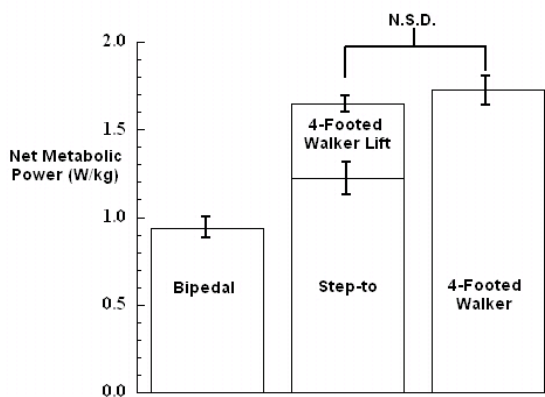


Figure 2: Mean values \pm SEM..

Our findings suggest that three principle factors contribute to the greatly elevated metabolic cost of using a 4F walker: slow speed, lifting, and the step-to gait.

The 4F walker involves a dramatically slower preferred walking speed (4F 0.35m/s vs. BP 1.52m/s). The metabolic cost of bipedal walking at 0.30m/s increased metabolic cost per distance by 73% compared to walking bipedally at 1.25m/s.

Lifting the 4F walker comprised 25% of the metabolic rate when using the 4F walker. Reducing the weight of 4F walkers could help mitigate the elevated cost of using these walkers.

The 4F walker requires the user to employ a ST gait. At 0.30m/s, ST walking unassisted was 29% more expensive than BP unassisted.

Using a 4F walker is an aerobically challenging task for elderly people. Using a 4F walker requires 90% of $\dot{V}O_2$ max in 85 year old community dwelling females, which is comparable to elite marathon runners.

Future walker designs should combat the three major problems we have identified. Ideally, such devices should provide the stability of a 4F walker, but allow the users to walk bipedally at a normal speed with no lifting required.

SUMMARY/CONCLUSIONS

Three principle factors contribute to the greatly elevated metabolic cost of using a 4F walker: slow speed, lifting the walker, and the step-to gait.

REFERENCES

- Holder, C.G., Haskvitz, E.M., Weltman, A. (1993). Journal of Orthopaedic and Sports Physical Therapy. **18**, 537-542.
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