Lower Extremity Loading During Aerobic Exercise: A Literature Review

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Introduction

Lower extremity wearable resistance (WR) has been used as a means of increasing physiological effects of aerobic exercise. There is limited research determining the effect of lower extremity WR on running mechanics. This review provides a summary of findings across eight studies that measured kinetics, kinematics, and spatiotemporal variables. Controversial data was found, and additional studies are needed to confirm findings. However, there is speculation that lower extremity WR could aid in sprint performance and running economy.

Purpose

The purpose of this review was to investigate the available information regarding the mechanics of lower extremity loading during aerobic exercise, with a focus on running studies.

Methods

A search of the TWU library data base was conducted. Studies had to have the following criteria:

- A focus on weighted running mechanics.
- Outcomes related to kinematics, kinetics, or spatiotemporal parameters.
- Excluded by lack of clear running outcomes or not having weighted conditions.

Eight peer-reviewed papers were included.

Keywords:
lower extremity loading, aerobic training, aerobic exercise, running, ankle weights, sprinting, kinematics, kinetics, mechanics, wearable resistance, biomechanics, running economy.

Results

Kinematics:

- Velocity
  - Decreased with WR when measured [1,3,6,8].
  - A literature review found controversial results with WR training [5].

Figure 2. Thigh and shank wearable resistance [9].

- Stride Length (SL):
  - No significant difference in SL with WR [1,3-5].
  - Significant decrease in SL was found with WR of 1% and 5% body mass (BM) [2]; while only a slight decrease trend was found with 0.45 kg (1 lbs) [3].
- Step Frequency (SF):
  - Controversial results have been found with WR training [5].
  - Significant decreases in SF with WR [6,7], while no significant difference was found compared to unloaded [4].
- Contact time:
  - Increased support time was found with WR [1-6].
  - No significant flight time differences were found with WR [1,3-6].

Results

- Joint angles:
  - Significant differences were found in knee flexion, hip extension, and plantarflexion with WR at 1%, 3%, and 5% BM vs unloaded [2].
  - At touchdown hip flexion increased, knee flexion increased, and plantarflexion had no significant differences. At mid-stance, hip extension, knee flexion, and ankle dorsiflexion increased. At toe-off, hip extension and plantarflexion decreased, while knee flexion increased [2].
  - Decreased plantarflexion during heel recovery at 3% and 5% BM; increased knee flexion during weight acceptance at 5% BM [8].

Figure 1. Ankle weights [10].

Kinetics:

- Ground Reaction Force (GRF)
  - Horizontal GRF and acceleration phase were increased with WR sprints [4,5], but it was not significant in the maximum velocity phase of a 6 second sprint at 5% BM [5].
  - Vertical GRF increased with WR of 3% and 5% BM [2,5,6].
  - No significant difference in GRF at 1%, 3%, and 5% BM; but an increase in impulse at 3% and 5% of BM [4].

Discussion/Conclusion

- Substantial amount of variability occurred among individuals when analyzing kinematics and kinetics [6,8].
- A case-by-case approach must be adopted to determine loading magnitude [8].
- Variability among magnitude and location of WR was also seen; a more distal load placement on the lower extremities (such as ankle weights compared to thigh and shank sleeves) had a greater effect on mechanics [6].
- Some studies determined that running with low-weight WR could improve sprint performance and running economy [4], aiding in a more efficient running economy based on the shortened SL that was found with WR at 1%, 3%, and 5% BM [2].
- Joint kinetics should be further assessed to determine how WR affects hip, knee, and ankle ROM in respect to running economy.
- Kinematics were minimally affected with lower body WR at 3% BM and proposed that WR of this magnitude could be used in training to increase sprint acceleration [7].
- WR training was recommended, in order to overload SF and other variables that would aid in short distance sprints and sprint acceleration [5].
- Ankle weights and other forms of lower extremity WR require further research to determine long-term effects of safety, running economy, and effectiveness.

References