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Metabolic Changes Between Three Hydration Load Configurations

Research Brief

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Abstract

Introduction: The need to investigate the impact of various types of Load Carriage (LC) in runners stems from the creation of wearable hydration pack systems configured to be worn on the back, waist, or carried in hands. Thus, the purpose of this study was to assess oxygen uptake (VO_2), heart rate (HR), and respiratory exchange ratio (RER) potential differences between three LC hydration configurations in recreational runners.

Methods: Ten college students (5 males and 5 females) who were active runners (ages: 20.1±1.7) completed three trials of a self-paced 5K on a treadmill (incline 1%). The three treadmill conditions were a self-paced 5K, one without a wearable hydration system (control condition), one with a backpack hydration system, and one with a handheld hydration system. Weight of external LC conditions (backpack and handheld) was equal (1.3kg ≈ 3lbs).

Results: Results from the three repeated measures ANOVA tests indicated an overall difference in VO_2 (F: 25.6, $p < .001$), RER (F: 76.9, $p < .003$), and HR (F: 21.7, $p < .001$) between the three trials. Post-hoc pairwise comparisons for VO_2 (38±4.3 vs 35.5±4.6; $p < .001$) and RER (.89±.007 vs .86±.01; $p < .002$) determined subject differences between the handheld trial and the unloaded trial. Significant HR pairwise comparisons were between the unloaded and the handheld trials (165.1±5.5 vs 167.6± 5.4; $p < .001$) and between the backpack and handheld trials (165.4±5.1 vs 167.6± 5.4; $p < .001$).

Conclusions: Running with a backpack and/or handheld hydration system may alter metabolic responses versus running without. Choosing a backpack hydration configuration or lack thereof may be more favorable for recreational runners due to improved running economy.

Key Words: Running, Backpack, Metabolic

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Introduction

The investigation of load carriage (LC) and its impact on treadmill performance (VO_2, RER) has occurred in mostly military populations[1,2]. Such research has focused primarily on either energetic cost or biomechanical alterations during low speeds, variations in gradient, and heavy loads[3,4]. Previous LC treadmill studies were designed to replicate the types of events encountered during tactical activities such as trekking, rucking, and hiking[5,6]. Therefore, very little data exists with non-tactical populations, such as recreational runners[7]. The need to investigate the impact of various LC in runners stems from the creation of wearable hydration pack systems designed to be worn on the back, waist, or carried in hands[8]. The current study investigated the impact of LC from three different hydration configurations (backpack and handheld) and no load (unloaded) on ventilatory responses (VO_2), heart rate (HR), and substrate utilization (RER) during running treadmill conditions. Greater insight into metabolic changes based on LC will assist in understanding the impact of hydration configuration on metabolic variables indicative of

run performance[9,10]. Results from this study will assist runners in making hydration system decisions by understanding which configuration produces the desired metabolic responses. The researchers hypothesized significant differences between all pairwise comparisons.

Methods

Participants

Following IRB approval and consent, ten college students (5 males and 5 females), who were active runners, completed three trials of a self-paced 5K on a treadmill (gradient 1%). The self-paced 5K was completed with the speed fixed the same for all three trials to achieve steady state. The ten participants (ages: 20.1±1.7) completed three trials with at least 48-hours between sessions.

Protocol

The three treadmill trials consisted of a self-paced 5K, one without a wearable hydration system, one with a backpack hydration system, and another with a handheld hydration system (one bottle per hand). Weight of each LC conditions (backpack and handheld) was equal (1.3kg ≈ 3lbs). Each of the three treadmill testing trials were self-paced in which the participant determined a fixed treadmill speed to be used for all three trials for the entire 5K distance. The treadmill gradient was set at 1% for the three trials for all participants. The three treadmill trials were conducted on days in which the participants had not previously exercised. For the control condition, participants completed the self-paced 5K without wearing a hydration system. For the backpack condition, the participants were fitted with a backpack hydration system and ran at their self-selected treadmill pace for 5K. For the handheld condition, the participants used a handheld hydration system (one bottle per hand) and ran the same self-selected treadmill pace for 5K. The order of treadmill trials for each participant was randomized. Mean VO_2, HR, and RER were measured using an iWorx GA-200A during each self-paced 5K treadmill trial.

Statistical Analysis

A randomized crossover design with repeated measures was used for this study. The Statistical Package for the Social Sciences SPSS (v24, IBM Corp., Chicago, IL, USA) was used for statistical analyses. Prior to data comparisons, a Kolmogorov-Smirnov test of normality and Mauchly's test of sphericity were performed for each of the three variables and determined the data to be from a normal distribution with equal variances. Three repeated measures ANOVA tests were used to compare mean VO_2, HR, and RER responses between the three trials. A post-hoc Tukey test of Least Significant Differences was used to determine significant pairwise comparisons for all three variables. The significance level was set at .05 for all data comparisons.

Results

Results from the three repeated measures ANOVA tests indicated an overall difference in VO_2 (F: 25.6, $p < .001$), RER (F: 76.9, $p < .003$), and HR (F: 21.7, $p < .001$) between the three trials. As reported by Table 1, post-hoc pairwise comparisons for VO_2 determined the main difference was between the handheld trial (38.0±4.3) and the unloaded trial (35.5±4.6; $p < .001$). A similar finding was detected with post-hoc comparisons between RER with a significant difference detected between the handheld trial (.89±.007) and the unloaded trial (.86±.01, $p < .002$). Post-hoc pairwise comparisons between HR determined significant differences between the unloaded and handheld trials (165.1±5.5 vs 167.6± 5.4; $p < .001$) and between the backpack and handheld trials (165.4±5.1 vs 167.6± 5.4; $p < .001$).

Table 1: Mean Results from Load Carriage Conditions with Significant Pairwise Comparisons

	VO2 (ml/kg-1/min-1)	HR (bpm)	RER (RQ)
Unloaded	35.5±4.6	165.1±5.5**	.865±.010
Backpack	36.1±4.2	165.4±5.1	.870±.012
Handheld	38.0±4.3*	167.6±5.4***	.898±.007****

*$p < .001$ (unloaded vs handheld); **$p < .001$ (unloaded vs handheld)
***$p < .001$ (backpack vs handheld); **** $p < .002$ (unloaded vs handheld)

Discussion

As stated earlier, previous studies on LC have focused primarily on military, tactical, and trekking populations. The target population for this study was recreational runners, hence, a self-paced 5K was selected as the treadmill protocol. In addition, a true hydration system was used for the two LC conditions

in the current study. Researchers Fagundes and colleagues[7] investigated similar variables with 12 adventure racers but used a maximal treadmill protocol with an external LC under three treadmill gradient conditions (0%, 7%, 15%). The LC condition in their study was a backpack without hydration configuration. The researchers reported no significant differences in VO_2max, HRmax, and RERmax between three treadmill gradient conditions. In the current study, mean VO_2, RER, and HR varied significantly between the unloaded and handheld trials. Such changes may be attributed to increased upper body locomotor movement with the load being removed from the center of gravity and increased metabolic demand (core temperature and catecholamine responses).

A recent study by Vincent and colleagues[8] investigated biomechanical and metabolic responses to four 5-mintue self-paced treadmill conditions. For their study, LC was represented by hand-held bottles (full and half-full) and a hydration belt worn around the waist. Results from the Vincent study reported no significant differences in VO_2, HR, and RER between the four treadmill conditions. In the current study, a significant difference was detected in VO_2, HR, and RER between the unloaded and hand-held LC conditions. The authors hypothesize an altered center of gravity may have contributed to the differences in ventilitory and substrate responses between the unloaded and hand-held condition. Differences in HR between the backpack and handheld conditions may be attributed to cardiac drift experiences with prolonged exercise with increased workload that can disturb steady state.

Results from the current study provide insight into metabolic responses from three hydration system configurations (1.3kg). A self-selected 5K was used for the treadmill protocol to maximize inferences to recreational running populations and to replicate steady state exercise. Of the three conditions, handheld bottles appeared to influence running economy more than the backpack condition. Runners who choose to carry an external hydration system may benefit from selecting a configuration that places the load closer to the center of gravity.

Media-Friendly Summary

A recent study investigated metabolic responses in recreational runners using a backpack, handheld, and no hydration system. Results from the study indicate runners may experience more metabolic strain when using a hand-held hydration system.

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