Influence of Carrying a Backpack on Pedestrian Safety

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Objective

University students walk frequently. They also represent an age group with among the highest pedestrian injury rates in the US. In fact, nearly 20,000 Americans ages 18-22 suffered serious pedestrian injuries in 2006; over 300 suffered fatal pedestrian injuries (National Center for Injury Prevention and Control [NCIPC], 2008). The crude rate for nonfatal pedestrian injuries is higher among Americans ages 18-22 than for any other developmental stage.

At all ages, pedestrian injuries are caused by a combination of factors, including driver behavior, pedestrian behavior, and characteristics of the traffic environment (Barton & Schwebel, 2007; Duperrex, Bunn, & Roberts, 2002). One factor that remains poorly understood, but which may contribute to increased risk of pedestrian injury among college students, is the fact that students tend to carry heavy backpacks.

Previous work indicates both physical and perceptual consequences of carrying a heavy backpack. Physically, carrying a backpack causes a decrease in walking speed, as evidenced by research in samples of adolescent girls (Chow et al., 2005) and college students (Wang, Pascoe, & Weimar, 2001). This decrease results from a combined tendency for backpack-wearers to take shorter steps (reduced stride length), to take fewer steps per minute (reduced cadence), and to spend more time on both feet (double support time) rather than just one foot (single support time). Perceptually, carrying a backpack appears to alter perception of steepness and distance (Bhalla & Proffitt, 1999; Proffitt, Stefanucci, Banton, & Epstein, 2003). In one study, for example, college students wearing a backpack weighing 16-20% of their body weight perceived distances to be farther than matched participants not carrying a backpack (Proffitt et al., 2003).

The present study was designed to compare pedestrian safety in college students while carrying a backpack and while walking without carrying anything. Because carrying a heavy backpack apparently disrupts normal walking behavior and perception, we hypothesized students who carried a heavy backpack (12% of their body weight) might demonstrate riskier pedestrian behaviors. Specifically, we predicted a slower walking speed and misperception of the environment would cause students to choose smaller and riskier traffic gaps to cross within, and to experience more close calls and collisions while crossing streets carrying a heavy backpack.

Method

Participants: Ninety-six college students were recruited and eligible to participate in this study from introductory psychology courses at the University of Alabama at Birmingham. The sample was 62% female and racially diverse (51% Caucasian, 30% African American, 6% Hispanic, 5% Asian American, and 7% multiracial or of other racial/ethnic groups). Mean age was 21.65 years (SD = 5.15).

Protocol: Following informed consent procedures, anthropometric measurements (height and weight, plus weight of actual backpack/bag(s) being carried) were taken. A standard backpack was filled with textbooks and notebooks to weigh 12% of the participants' body weight; this backpack was used for the remainder of the session with that participant.

The participants viewed a mid-block crosswalk on a road with bi-directional traffic in an immersive, interactive virtual environment (Schwebel, Gaines, & Severson, 2008**;** See Figure 1). Participants crossed a total of 20 times in the pedestrian environment. Ten of those trials were completed while wearing the backpack and the other ten trials were completed without any burden. Order of trials (backpack vs. no backpack) was determined randomly between participants.

Measures: Six outcome measures were considered:
1. Walking speed
2. Start delay (how long after car passes before participant enters road)
3. Gap entered (time between participant entering street and the next car arriving in crosswalk)
4. Time left to spare (time between participant safely crossing street and the next vehicle arriving)
5. Missed opportunities (when a traffic gap was sufficiently large for the participant to cross within, but he/she did not cross)
6. Hits/close calls (when the participant would have been hit or almost hit in the real environment)

Figure 1. Virtual Reality Environment Crosswalk

Results

The primary hypothesis, that carrying a backpack would influence safe pedestrian behavior, was tested using paired-samples *t*-testS for each of the six dependent variables. As shown in Figures 1-4, there were significant differences on four of the six dependent measures. Replicating previous work (Chow et al., 2005; Wang et al., 2001), participants tended to walk somewhat slower while carrying the backpack (M = 2.81 miles per hour, SD = 0.41) than while not carrying the backpack (M = 3.00, SD = 0.41).

Carrying a backpack also resulted in less time to spare after safely crossing the street (M = 3.90 seconds, SD = 1.04 with backpack; M = 4.16, SD = 0.94 without), fewer missed opportunities (M = 0.07, SD = 0.30 with backpack; M = 0.22, SD = 0.71 without), and more hits/close calls (M = 0.61, SD = 0.80 with backpack; M = 0.42, SD = 0.74 without). Differences between carrying a backpack and not carrying a backpack were not significant on the gap entered or start delay variables.

Multiple regression models (not shown) suggested the findings held across all subgroups in the sample; age, race, gender, BMI, frequency of walking, frequency of carrying a backpack, and weight of backpack carried to experiment were not consistent predictors of pedestrian safety independently or in interactions with backpack condition.

Figure 1. Walking Speed

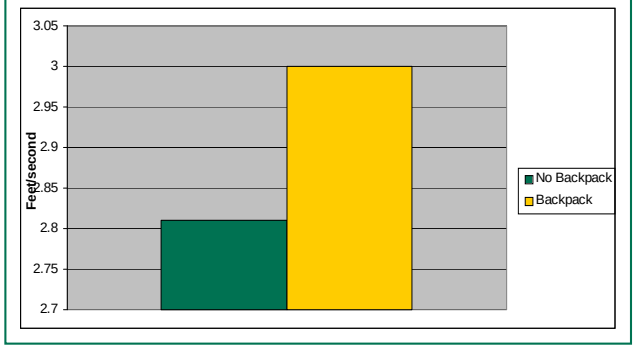


Figure 2. Time Left to Spare

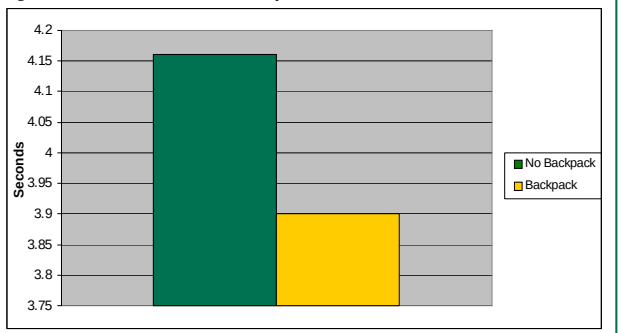


Figure 3. Missed Opportunities

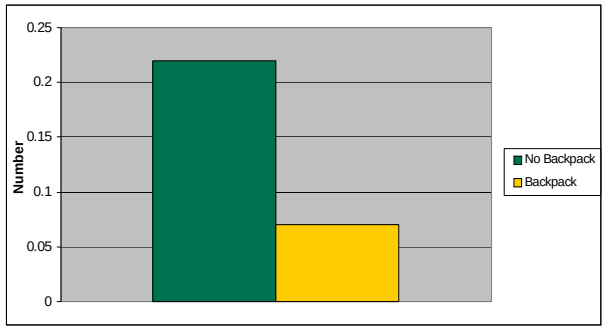
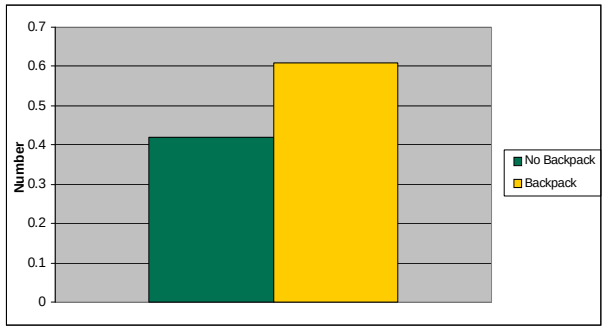


Figure 4. Hits/Close Calls



Conclusion

Carrying heavy backpacks might disrupt safe pedestrian behavior. While wearing a backpack, college students walked more slowly, which caused them to leave less safe time to spare after crossing the virtual street and to experience more frequent hits/close calls. Our test of several covariates suggests the finding held across all subgroups in the sample.

It is important to note that the risk backpack-wearers experienced was due primarily to a slow walking speed rather than choosing less safe traffic gaps to cross within. In fact, participants tended to choose similar-sized traffic gaps when carrying or not carrying the backpack. Behavior in our virtual environment has been shown to match behavior in real-world settings (Schwebel et al., 2008), but participants in the virtual world do not have the opportunity to alter their walking speed partway across a street. Future research should evaluate aversive measures backpack-wearers might take in the real world that were not possible in our simulation. Pedestrians with heavy packs might, for example, quicken their slower walking speed mid-crossing to avoid potential collisions and close calls with oncoming traffic in a real-world environment.

Pending replication in future research, one implication of our findings is that university administrators, especially those on urban campuses, might consider institution of educational campaigns with students, alerting them of the need for increased alertness while crossing streets while carrying heavy loads. Traffic engineers might consider the fact that walking speed is reduced in individuals carrying heavy packs, and adjust traffic and crosswalk signals accordingly.

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