Back pain is an epidemic in the adult population with >60% of adults reporting having experienced back pain.1,3 Back symptoms are the second leading symptomatic reason expressed by patients in the United States for consulting physicians.4 The incidence of back pain in children and adolescents varies from 8%-84.1%.5-15 The reported incidence depends on the population studied and the definition used.16 The majority of low-back pain is mild.17 Growing concern exists among educators, health-care professionals, parents, and legislators that back pain is becoming a serious health issue in school-aged children due to the increased use of heavy backpacks.18

The carrying of heavy backpacks is common in the school-age population.2 Young children sometimes carry as much as 30%-40% of their body weight.2 The association of back pain with backpack use is controversial within the scientific literature with some studies finding no association and some finding an association. This review article studies the impact of backpack carrying on children studies the available scientific literature.

**Prevalence and Risk Factors for Back Pain**

The prevalence of nonspecific back pain increases dramatically during adolescence from <10% in preteens to 50% in 15- to 16-year olds.11,19 The most frequent increase in the prevalence of reported back pain occurs in girls aged 12-13 years and in boys aged 13-14 years.20 Viry et al15 noted that this period corresponds to the time of puberty and maximum linear growth. It is known that back pain at a young age is an important factor in the risk of experiencing back pain as an adult.2,21

Most authors have reported the following associations with back pain: gender (higher prevalence in females),11,13,15,22-24 poor general health,11 a family history of back pain,5,13,15 psychological profile,5,16,22,25-28 time spent sitting or watching television,11,13,23,29 heavy backpack weights,11,14 exposure to backpack loads (time spent carrying loads),11,23,30 increased back flexor strength,9 high growth rate,26 tight hamstrings,26 tight quadriceps femoris,26 previous back injury,13,14 low physiologic maximum lumbar spine mobility,31 increased body mass index,24,32 and age (more back pain at older age).8,9,12,13,17,23,29 Although one study suggested that low levels of physical activity are associated with back pain in adolescents,33 other studies have found that high levels of physical activity9,13,14 and participation in competitive sports5,13,17,19,23,24,29,34 are associated with back pain in adolescents.

In a systematic literature review of 56 journal articles reporting on 65 epidemiologic studies about body weight and low-
back pain, Leboeuf-Yde et al.\textsuperscript{20,35} concluded that if body weight was considered a possible weak risk indicator, insufficient data exists to assess whether it is a true cause of low back pain. In a systematic literature review of 41 journal articles reporting on 47 epidemiologic studies about smoking and low-back pain, Leboeuf-Yde\textsuperscript{36} concluded that smoking should be considered a weak risk indicator and not a cause of low-back pain.

**Backpack and Gait Analysis/Cost of Locomotion**

Walking with a heavy load changes posture: patients carrying a heavy load lean forward and raise their heads.\textsuperscript{2} Chansirinukor et al.\textsuperscript{37} revealed that both backpack weight and time carried influenced cervical and shoulder posture. Forward head posture increased when carrying a backpack, especially one with a heavy load. Carrying a backpack representing 15\% of body weight appeared to be too heavy to maintain standing posture for adolescents.

Cottalorda et al.\textsuperscript{38} analyzed the effect of different backpack carrying methods on gait kinetics in children. Forty-one children (mean age 12 years) participated in this study. The mean weight was 40 kg. The 3 trials consisted of walking on a treadmill at 3.5 km/h, first without a backpack and then carrying a 10-kg backpack, on one shoulder and both shoulders. When carrying a backpack on one shoulder and then on both shoulders the children walked with longer strides (time between two consecutive heel-on contacts), stance (portion of the gait cycle during which the foot is in contact with the ground), and double stance (time during which both feet are in contact with the ground) compared to walking without a backpack. These results were supported by Hong and Brueggemann\textsuperscript{39} and Kinoshita\textsuperscript{40} who noted that the double-
Improper backpack use can result in posture and gait changes.

Backpack Weight, Back Pain, & Structural Spinal Deformity

Does low-back pain in childhood predict low-back pain in adulthood? Few longitudinal data are available. Harreby et al^7 used a questionnaire to collect data from a cohort of 578 adults aged 38 years who had participated in a study of schoolchildren conducted 25 years earlier. In patients with a history of low-back pain during childhood, the odds ratio (OR) for low-back pain in adulthood was 2.23 (confidence interval: 1.00–4.97). Mirovsky et al^8 had similar findings; 62% of the children in their prospective study reported pain after maturity.

Orthopedics surgeons should pay careful attention to the identification and management of risk factors for low-back pain. Postural changes in the spine occur when heavy backpacks are carried. Two-strap backpacks and no backpacks. Pascoe et al^41 concluded that carrying a 10-kg schoolbag affects gait kinetics and that children should carry their backpacks on both shoulders rather than use a one-strap backpack.

Pascoe et al^41 investigated the impact of backpacks on 10 children aged 11-13 years using measurement of static posture and gait kinematics. The children participated in tests under four conditions: no backpack, one-strap backpack, two-strap backpack, and one-strap athletic bag. Pascoe et al^41 also noted that carrying one-strap bags caused a shoulder elevation and a curvature of the spine away from the weight of the backpack. In their study, shoulder elevation from a horizontal position and lateral spinal deviation was not significantly different between two-strap back packs and no backpack. However, one-strap athletic bags promoted lateral spinal bending and shoulder elevation, while the two-strap backpack significantly reduced the stresses of carrying backpacks. Pascoe et al^41 concluded that the daily physical stresses associated with carrying athletic bags on one shoulder significantly alter the posture and gait of young people. These alterations of the spine may be responsible for the perceived back pain (51%) reported in their study. ^41

The mean backpack weight in United States was 7.7 kg, which represented 17% of the student’s mean body weight. Students in Hong Kong carried backpacks weighing approximately 20% of their body weight. The recommended backpack load limit for physically fit adults is 30%–28. Of Italian schoolchildren, 34.8% regularly exceeded this load limit. In the study by Viry et al,^15 the mean backpack weight was 9.6 kg, which corresponded to 19.2% of the mean child’s weight, and 49% of children were carrying backpacks that weighed >20% of their body weight. Viry et al^15 reported that carrying a backpack weighing >20% of the bearer’s body weight was significantly associated with back pain within the previous year and with back pain requiring a physician visit (adjusted OR, 3.1 [P<.05] and 5.2 [P<.01], respectively).

In a cross-sectional study of 1126 children, aged 12-18 years, Sheir-Neiss et al^11 reported that the use of backpacks during the school day and backpack weight are independently associated with back pain. However, in this study adolescents with back pain were more likely to carry a heavier backpack and to use their backpack more during the school day. Adolescents without back pain were more likely to attend schools that banned carrying backpacks between classes.

Negrini and Carabalona^10 found an association between back pain and time spent carrying backpacks, but not between back pain and backpack weight. Viry et al^15 found an association between back pain and walking to and from school, only if the relative backpack weight was >20% of body weight. Wall et al^18 found that only 0.3% of children


