5. N. Tyrer and E. Bell, *Brain Res.* **73**, 151 (1974).
6. The cobalt ions never traveled more than 15 to 16 mm in any of these experiments or in concomitant experiments where the optic nerve was filled instead of the tract. This limitation indicates that the branches are formed at the optic chiasma: from the point of injection on one side to the geniculate nuclei on the opposite side (by way of both optic tracts through the optic chiasma) is about 15 mm.
7. I thank M. Segraves for expert histological assistance, R. Malinsky for photographic work, and M. Murray and M. Goldberger for valuable criticism. This work was supported by NSF grant BMS 74-24088.

12 May 1976; revised 27 July 1976

Carrying Behavior in Humans: Analysis of Sex Differences

Abstract. *Behavioral differences between the sexes include methods of carrying books. Females clasp books against their chests; males carry them at their sides. In kindergarten and the first grade, both sexes carry like mature males. Sex-typical carrying appears before adolescence. Behavioral differences seem to be primarily a consequence of morphological differences and social modeling.*

Male and female college students differ consistently in their methods of carrying books. The results of our studies on carrying behavior of college students in Montana, Ontario, New York, El Salvador, and Costa Rica all show similar sex differences (*1*) and are in agreement with studies in Tennessee (*2*). College females usually wrap one or both arms around their books, which they rest on their hips or clasp against their chests. College males carry books in one hand at the side of the body. This behavioral difference must be widely known and recognized (*3*), but it has usually been ignored as a subject of study.

We classified book-carrying behavior into eight categories, but it is sufficient here to combine them into two basic types (Fig. 1) and to group the other categories as "other." In type I, one or both arms wrap around the books; the forearm, on the outside of the books, supports them. The short edges of the books rest horizontally against the body on top of the hip or in front of the body in line with or higher than the hips. When books are carried in one arm, the fingers wrap around the long edges. When they are carried in both arms, the fingers wrap around contralateral edges or grasp contralateral forearms or wrists. In type II, books are supported by one arm and hand at the side of the body, with the long edges approximately horizontal. The hand may be above the books, pinching them between the thumb and the fingers, or on the outside of the books with the fingers wrapped around the lower edges. When the elbow is flexed and the books are raised, the long edges sometimes rest on both the hand and the forearm or wrist. Other methods include a variety of unusual, infrequent methods such as resting the books on the shoulder or head.

Our initial discovery that 92 percent of females at the University of Montana carried their books according to type I and 95 percent of males carried according to type II was confirmed in widespread locations throughout North and Central America (*1*). Sex differences in strength or in load size do not explain the behavioral difference. Both females and males carry both large and small loads typically for their sex (*1*). A detailed study of book carrying, weight of books, and grip strength failed to reveal any causal relationship among these variables (*4*).

Differences in morphology of physically mature individuals may contribute to the differences in carrying. Ratios of hip width to shoulder width are different for males and females. Not only is the female hip relatively wider than that of the male, but fat over the iliac crest gives it a more shelf-like quality (*5*). In most females, the carrying arm could not hang vertically but would have to angle outward. Males and females also differ in the angle at which the forearm attaches to the arm.

The differences in book carrying might also be an expression of sex differences in body postures and in the way the limbs are held. Females tend to assume more closed positions than males; they more often fold their arms in front of the body and cross their legs or keep them together. Male positions tend to be more open or exposed (*6*). Similar postural differences were found in a comparative study of 480 human cultures (*7*) and in studies of other primates (*8*). This raises the possibility that these differences may in part be genetically determined. Certainly the female carrying methods result in positions that are more closed, with the arms and books partially covering the front of the body; male carrying methods result in open positions that leave the body unobstructed.

First-grade school children in Montana lacked both the sex differences and the rigid stereotypy typical of college students. The differences developed most rapidly during the junior high school years. To determine more precisely when these changes in behavior occur, we recorded the spontaneous book carrying methods of 2256 individuals from kindergarten through old age in Ithaca, New York, between October and December 1975. We made a single record of each individual's carrying method as he entered an arbitrarily defined space. All data were combined into types I, II, and other, and into ten levels: kindergarten through grade 1; grades 2 and 3, 4 and 5, 6, 7, 8, 9, and 10 through 12 (high school); college; and mixed-age adults.

In the kindergarten and grade 1, there are no significant differences in carrying behavior between males and females

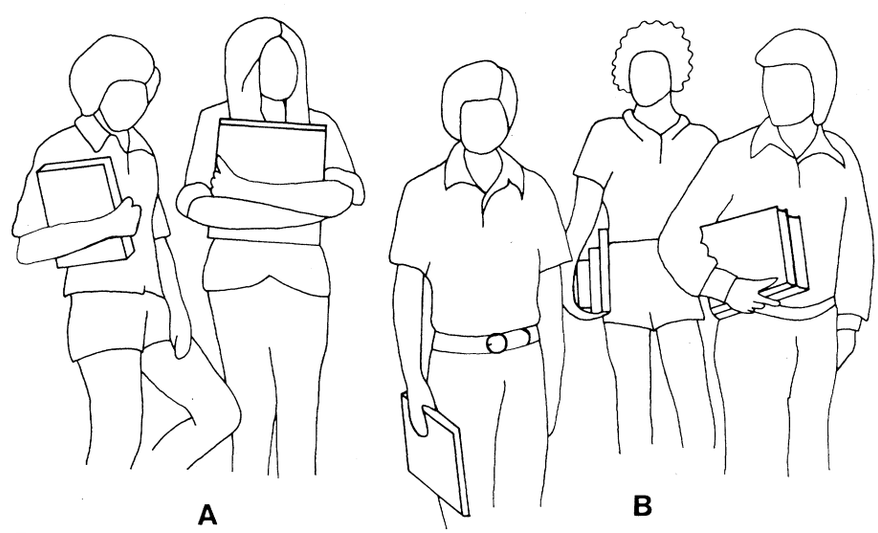

Fig. 1. Methods of carrying books. (A) In all type I carrying methods, the short edges of the books rest on the hip or in front of the body. (B) In type II methods, the books are either pinched from above or supported from below by the hand or the hand and arm.

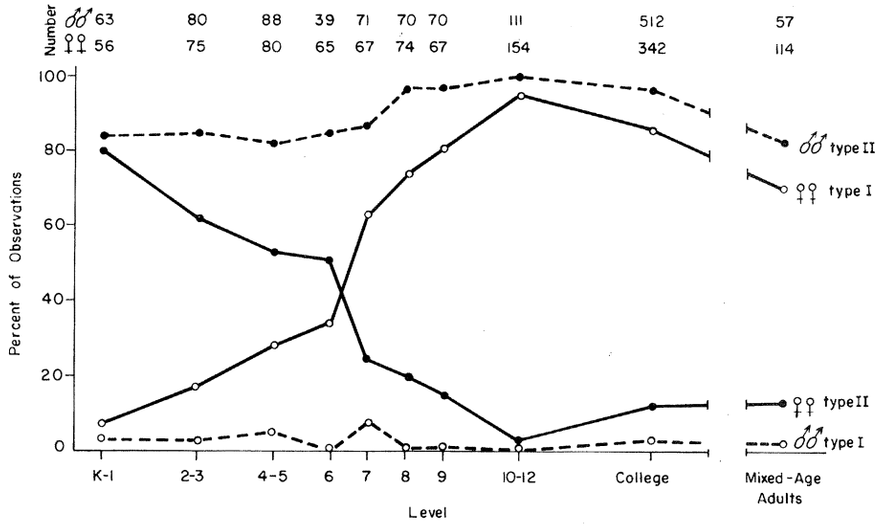

Fig. 2. Percentage of males (broken line) and females (solid line) that carry according to type I (hollow circles) or type II (solid circles) at different levels. Sample sizes are shown across the top. When the sum for a sex at any level is less than 100 percent, the rest used other methods.

($P > .50$). Children of both sexes, like college males, usually use some variant of type II. However, in grades 2 and 3 and at all subsequent levels, there are significant differences between the sexes ($\chi^2 = 12.75$, d.f. = 2, $P < .01$ for grades 2 and 3; all other χ^2 values are greater).

The proportion of females using type I carrying methods increases linearly from kindergarten through grade 1 to high school ($r^2 = .94$), while the proportion using type II decreases. After high school the proportion carrying according to type I decreases (Fig. 2). There are no level-to-level significant differences between females until grade 7 (*9*). In Tennessee, significant differences were found in females between grade 6 and grades 7 to 9 combined (*2*).

Although males also change their behavior over time, 84 percent in kindergarten and grade 1 already carry like older males (Fig. 2), and there is no significant change between any two adjacent levels. [The largest increase in type II carrying, between grades 7 and 8, is not significant ($P < .10$)]. The sex difference after grade 1 is primarily a consequence of females shifting their behavior from carrying methods typical of males to those typical of females.

The sex difference in the ratio of hip width to shoulder width is a consequence of differential growth rates during adolescence (*10*). The greatest increase in type I carrying by females coincides with the onset of female adolescence (*11*). The continued increase in type I carrying from grade 7 to high school may reflect the increased proportion of females entering adolescence. However, the sex difference in carrying begins to appear before adolescence (from grades 2 and 3), when body proportions of males and females are identical (*5*). Morphological differences also cannot explain the significant decreases in the proportion of females carrying according to type I after high school.

The most reasonable explanation for the early development of female-typical carrying behavior is social modeling. There are older children of the same sex to imitate, teachers to copy, and an increased awareness of sex roles brought on in many ways, including separate bathrooms for boys and girls, lining up boys and girls in separate rows, and pressure for sex conformity from older schoolmates. The decrease in sex-typical carrying after high school is probably a consequence of decreased tendencies toward peer group conformity, which is very important in high school (*12*).

The importance of cultural differences was demonstrated by 147 female and 128 male *colegio* students (grades 7 through 11) observed in Turrialba, Costa Rica, during March 1976. Females and males carried books differently ($\chi^2 = 66.94$, d.f. = 2, $P < .001$), but only 39 percent of females used type I methods and 55 percent used type II. In New York, 82 percent of females in grades 7 through 12 ($N = 362$) used type I; only 12 percent used type II. The difference between females in New York and Costa Rica was significant ($\chi^2 = 105.46$, d.f. = 2, $P < .001$.) There was no cultural difference in males ($P < .20$). In Costa Rica, 97 percent, and in New York, 96 percent ($N = 322$) used type II (*13*). The importance of peer modeling was demonstrated by the Costa Rican students who used other methods. Almost all of these students tucked one or two books inside the waistbands of their pants or skirts. This method was never observed in New York.

The difference in book carrying behavior of males and females seems to be a consequence of the interaction of several factors. (i) We cannot discount the possibility of a genetic predisposition for females to assume more closed positions than males. (ii) Because of the sex differences in hip width, hip shelf, and lower arm angulation between physically mature males and females, some carrying positions are probably more comfortable or less fatiguing for one sex than for the other. (iii) Interacting with these relatively fixed sexual differences is learning. Certain methods may come to be preferred through practice. Social modeling may explain the regular increase in the adult female type of carrying among preadolescent females.

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9. There are significant differences in females between grades 6 and 7, grade 9 and high school, high school and college, and college and mixed-age adults (all $\chi^2 \geq 12.17$, d.f. = 2, $P < .01$).
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11. Although there is much individual variation, the adolescent growth spurt in females typically begins at age 11, peaks at 12, and slows by 13½ [J. M. Tanner, R. H. Whitehouse, M. Takaishi, *Arch. Dis. Child.* **41**, 455 (1966)]. The age range for grades 6 through 7 in Ithaca is 10.8 through 12.7 years.
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13. In Costa Rica, no male *colegio* students used type I carrying and 3 percent used other methods. In New York, 2 percent used type I and 2 percent used other methods.
14. We thank the central administration and principals of the Ithaca public schools for permitting us to observe students within the schools. We thank G. Burghardt, T. Hanaway, and P. Spottswood for sharing the results of their research in Tennessee.

11 May 1976; revised 27 July 1976