CHAPTER 13

Development and Maturation of Throwing and Clubbing

"A step in the direction of the ball, a forward rotation of the hips and spine, and the uncocking of the arms and wrists. In essence, this is the mature pattern for all striking skills"
[Wickstrom, 1977, p. 163].

"...both striking and throwing represent tasks with similar purposes... that can be performed using similar biomechanical actions"
[Langendorfer, 1987, p. 45].

[*In children] "The magnitude of the [gender] difference in throwing is remarkable and is out of proportion to those in any other physical measure"*
[Espenschade, 1960, p. 432].

Introduction. Is throwing and striking behavior inherited or learned? Is it based upon an innate ontogenetic process or is it a cultural product dependent upon teaching or other societal factors? This question, recently examined for the first time [Young, 2009, 2010], will be further explored in this chapter. The conclusion is reached that throwing and club-swinging behavior in humans is dominated by a genetic element. Teaching, learning, practice and various other societal influences may play a role, but they are less significant than the influence of biological inheritance.

There is an inherited motor pattern that emerges shortly after birth in all human children, yields a single type of bipedal throwing motion, is characterized by a gender disparity (boys have a significant advantage), develops with increasing age, involves remarkable complexity and rapidity, and in young adults reaches an exceptionally high level in a small number of elite athletes, most of whom are males. The same pattern is seen during the ontogeny and maturation of striking. The two behaviors share a sequence of similar biomechanical movements involving the entire body in a motion which begins in the lower extremities and generates a growing pulse of kinetic energy that is ultimately transmitted to a hand-held implement. The same throwing and striking motions develop without teaching in all ethnic groups and cultures. In short, all humans throw and swing clubs the same way as an outcome of a universal, human ontogenetic program. This evidence requires an *evolutionary explanation*.

Mayr [1961] called an evolutionary explanation the "ultimate cause" of a heritable behavior because it reflects the history of natural selection of the set of genes that underlie the behavior. The "proximate cause" (in an individual) is the interaction of these selected genes with environmental factors to yield mature individuals with an ability to throw a projectile or swing a club from a bipedal stance.

The evolutionary explanation to be proposed will be familiar to the reader who has proceeded this far: It is based on the concept that throwing and clubbing behavior was naturally selected because it yielded reproductive benefits to our ancient ancestors.

The development of throwing in young children. This research field was originated over seventy years ago by Wild [1938], whose pioneering investigations had a great and enduring impact on the field of science it created [Wickstrom 1977]. Wild filmed 32 right-handed children from Iowa between the ages of 2 and 12 years while they performed overhand throws. By analysis of the extensive movement and timing data she collected, Wild reduced throwing development to four age-related stages.

In Stage I, children 2-3 years old threw from an upright stance with a simple arm movement. The flexed arm was first moved high above the shoulder with trunk extended and the body facing forward. Then the trunk flexed forward as the elbow extended and the arm swung over the shoulder and down in front. In Stage II, ages 3.5-5 yrs., a horizontal rotation was introduced. The feet remained together in place, but now the body rotated right, then back to the left as the right arm extended and swung forward. Stage III (ages 5-6) added a step forward to the motion, although sometimes it was the right foot that moved forward with a right-handed throw. Stage IV was recorded in all boys 6.5 yrs and older but few girls. It involved a weight shift to the right foot as the trunk rotated rightward and the throwing arm was swung upward and back, followed by a step forward by the left foot. This forward weight shift was accompanied by forward trunk rotation, horizontal adduction of the throwing arm and extension at the elbow. The girls had fallen behind. Most of them displayed the body and foot movements, but had less advanced arm movements, and some had regressed to earlier stages.

In other early research, H. Halverson [1940] found that children first throw from a sitting posture before being able to stand, then throw bipedally when they are able to maintain upright balance. Boys outperform girls in throwing delivery, accuracy and distance by 3.5-5 years.

These pioneering reports showed that throwing behavior begins shortly after birth and then becomes more complex as it develops into a rudimentary version of the motion employed by mature athletes (Figure 11, p. 188). Boys outperform girls in maturity of the throwing motion and the distance (or velocity) of the throw.

Confirmation of early studies. The emergence of a standardized overarm throwing motion and a notable gender difference in its development proved to be a feature of child development wherever it was studied, including Japan [Sakurai and Miyashita 1983], Mexico [Malina and Buschang, 1985], Nigeria [Toriola and Igbokwe, 1986], New Guinea [Malina, et al., 1987], Senegal [Bénéfice and Malina, 1996; Bénéfice, et al., 1999], Tasmania [Cooley, et al., 1997], England [Marques-Bruna and Grimshaw, 1997], Brazil [Teixeira and Gasparetto, 2002], Germany [Ehl, et al., 2005], Australia [Thomas, et al., 2010], and many samples of children in the United States [Keogh, 1965; Wickstrom, 1977; Morris, et al., 1982; Malina, et al., 1987, and others cited below].

Very young children, under the age of 3, and preschoolers, ages 3-5 yrs from diverse cultures and ethnic groups are all able to throw. Even undernourished children, with reduced body size that adversely affects their throwing performance, show an age-related increase in skill and a gender disparity [Malina and Buschang, 1985; Malina, et al., 1987; Bénéfice and Malina, 1996; Bénéfice, et al., 1999]. They all throw with the same throwing motion, which develops in the same developmental sequence. There are no reports of unusual throwing styles.

Development of throwing skill is variable. Roberton [1977] initiated the analysis of different body components during childhood development of throwing. This approach revealed variation of individual pathways [Roberton and Langendorfer 1980]. It also disclosed refinements in the throwing motion that appear late in development, including rotation of hips before shoulders, shoulder motion before humerus, humerus before the forearm [Halverson, et al., 1982]. In some individuals, development stops before these late refinements are installed [Leme and Shambes, 1978; Atwater, 1979; Williams, et al., 1998]. This occurs more frequently in girls.

The developmental gender difference in throwing. From infancy through childhood the average performance of boys in throwing (velocity and distance) exceeds that of girls [Wickstrom, 1977]. This disparity surpasses in magnitude the gender difference in any other motor skill [Espenschade, 1960]. Gender differences detected at age 3 are already three times larger than in other motor behaviors [Roberton and Langendorfer, 1980; Thomas and French, 1985]. Keogh [1965] found that boys age 8 could throw farther than girls age 11. Boys in first grade threw faster and farther than girls in grade 4 [Rippee, et al., 1990] and boys in grade 2 had a more advanced throwing motion than girls in grade 5 [Butterfield and Loovis, 1993].

In a 1979 investigation of 13-year-old children from Wisconsin, boys threw on average 6.6 m/s faster than the girls [Halverson, et al., 1982]. In 1999, the same research team [Runion, et al., 2003] studied a similar sample from Ohio. The ball velocities and between-sex differences had not changed during 20 years. Next, the group applied the study protocol to 13-year-old German youths with different cultural influences [Ehl, et al., 2005]. (In Germany, many more youths

play soccer than any throwing sport, a contrast to the emphasis on baseball and softball in the US). Although the US youths threw faster, the disparity between boys and girls in throwing velocity was identical in Germany and the US (6.9 m/sec)—comparable to the two US cohorts separated by 20 years.

Petranek and Barton [2011] studied a group of 38 girls (mean age 13.7 years) from a US softball league. Most of the girls (90%) practiced three or more times per week; many (83%) had been playing for 6-9 years [Petranek and Barton 2011]. Compared to girls of the same age with less experience from the US [Runion, et al., 2003] and Germany [Ehl, et al., 2005], they threw with greater velocity (2.8 m/s and 4.8 m/s faster, respectively), but the boys from the US and Germany still threw with more velocity than the more experienced softball players (4.1 m/s and 2.2 m/s, respectively) [Petranek and Barton, 2011]. The results are not directly comparable, due to differences in methods (in the early studies children were randomly selected from schools and threw tennis balls with much less mass than softballs), but they call attention to the continuing gender gap in throwing at about the time of puberty.

Throwing *accuracy* (distinct from velocity or distance thrown) has seldom been analyzed, but limited evidence suggests a male advantage in very young children. Keogh [1965] studied accuracy of the throw in 337 children ages 7-9 years. He recorded an improvement with age and a superiority of boys over girls at each age, even though boys threw from 1.5 m farther from the target. Wickstrom [1977] found a similar annual improvement in throwing accuracy among 960 children 6-9 years of age. Boys were more accurate than the girls at each age. Other studies have also found that boys outperform girls in tests of accuracy [Hicks, 1958; Thomas and French, 1985; Rippee, et al., 1990].

What causes childhood gender differences in throwing? There is no gender disparity in either static or dynamic balance [Keogh, 1965; Morris, et al., 1982; Thomas and French, 1985; Ulrich and Ulrich, 1985; Toriola and Igbokwe, 1986; Butterfield and Loovis, 1993, 1998]. Physical factors are not likely to be involved. Gender sameness prior to puberty is the rule in body type, composition, strength, limb lengths, height and weight [Keogh, 1965; Thomas and French, 1985; Bénéfice, et al., 1999; Thomas, 2000; K. Thomas, et al., 2001]. Nor is there any known physiological, anatomical or maturational basis to account for the gender difference [Nelson, et al., 1986, 1991; Butterfield and Loovis, 1993, 1998]. It is not until puberty that numerous changes occur which accentuate the pre-existing male advantage (Chapter 5).

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