

# WOOD IN SPORT EQUIPMENT

## HERITAGE, PRESENT, PERSPECTIVE



Edited by  
Francesco Negro

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The icons represent some of the sports considered in the book (including all sports would have resulted in too small images for proper visualization). The wooden equipment is outlined by the colors of the wood species from which it is made, and by lines representing the grain of wood and the characteristics of the relative wood-based products.

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## BREAKING WOOD, ON THE WAY TO THE BLACK BELT

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### INTRODUCTION

Taekwondo is a martial art that originated in Korea around 50 BC. Its name means “the way of kicking and punching” and comes from the Korean words “tae” (feet or kick), “kwon” (fist or punch), and “do” (path or realization) [1].

Taekwondo is a highly spectacular sport that involves several physical skills such as agility, flexibility, and endurance. This is just a part of it, the other being the development of mental aspects and ethics. The concept of “do” is indeed key in this discipline: both the body and the mind are trained and applying the acquired principles in one’s life is encouraged. The elements encompassed are courtesy, integrity, perseverance, self-control, and indomitable spirit (Kim et al. 2021). Thanks to its wide range of educative values, taekwondo is taught worldwide as a way to maintain physical and mental well-being (Petrovic 2017).

Taekwondo entered the Olympics as a demonstration sport at the 1988 Olympic Games in Seoul, and then became an official sport at the 2000 Games in Sydney [1]. Nowadays it is practiced in more than 200 Countries, many of them having large federations and boasting world class athletes.

The wooden breaking boards used in taekwondo are the subject of this chapter. Similar boards are used in other martial arts as well, for instance in karate. In line with the general approach of this book, only taekwondo is considered here to avoid additional information that would be largely repetitive.

### WOODEN BREAKING BOARDS

Wooden breaking boards are used for various purposes in taekwondo: for professional and amateur training, in formal tests to attain

belt ranks, in freestyle competitions, and in exhibitions (boards made of synthetic materials and bricks are also used). In taekwondo, wooden boards are broken mostly with a kick, but also with the fist. The break provides a double, immediate feedback of the blow: that it is executed accurately, and the force applied is adequate.

Wooden breaking boards are typically made of solid wood or of solid wood panels (that is, of wooden laths glued side by side). Their width and length are typically 30 x 30 cm or 25 x 30 cm, whereas the thickness varies depending on the intended use. Generally, 0.4-0.7-1.0 cm thick boards are suitable for kids training, 1.5 cm thick boards are used in competitions and for average level training, and 2.0-2.5 cm thick boards are used at advanced level and in exhibitions. In some cases, boards are stacked to further challenge the skills of the athletes. Boards can be broken individually or in sequence: in this case, combinations of acrobatic movements unfold in a few seconds, resulting in highly spectacular releases of energy and broken wood. In some exhibitions, broken boards are signed by performers and given to the audience, which somehow confirms the iconic role of these items.

Clearly, wooden breaking boards are intended to represent a feasible challenge: after all, and as stated above, the difficulty of the exercise can be easily increased by stacking multiple boards. Mid-low density wood species are used, especially pine (450-520 kg/m<sup>3</sup> at 12% moisture content), spruce (460 kg/m<sup>3</sup>), and paulownia (280 kg/m<sup>3</sup>) (EN 350; [2]).

Wooden breaking boards used in taekwondo typically derive from the radial cut

of round timber. Noteworthy, the strike shall be done parallel to the wood grain (FIGURE 30.1). This can be explained by recalling the classic lecture demonstration in which a bunch of sticks, like *spaghetti*, is used to represent the structure of wood as a bundle of linear cellulosic fibrils. These consist of the union of polysaccharides (especially glucose) connected longitudinally and laterally to each other by chemical bonds of different binding

energy and resistance to hydrolysis, which are much higher along the longitudinal union. Consequently, it is easier to separate the sticks laterally than to break them by tensioning the bunch in a direction parallel to its length. Similarly, wooden breaking boards are essentially broken by separating the wood fibers from each other, along roughly straight breaking lines.

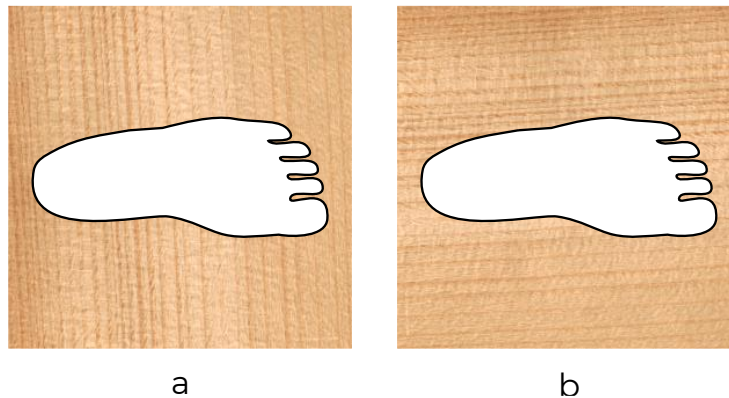


FIGURE 30.1 Relative orientation of foot and wood grain, as seen from the kicker's point of view: perpendicular in (a), correctly parallel in (b) [image F. Negrol].

### THE PHYSICS OF BREAKING WOODEN BOARDS

Breaking a wooden board is a practical and spectacular application of the impulse-momentum theorem.

The momentum is defined as the product of an object's mass and its velocity<sup>51</sup>:

$$\mathbf{p} = m\mathbf{v}$$

Any massive object that is moving has a momentum: the greater the mass or velocity of the object, the greater the momentum.

Impulse is a physical quantity that can be determined as the product of the average force  $F$  acting on an object and the time interval  $\Delta t$  in which the object experiences the force:

$$\mathbf{I} = \mathbf{F}\Delta t$$

The impulse-momentum theorem states that the change in momentum of an object equals the impulse applied to it:

$$\mathbf{F}\Delta t = \Delta\mathbf{p}$$

This law can be used to understand how a quick blow can break hard objects like wooden

boards. Let's consider the arm moving towards a board. When the hand hits the board, its impulse rapidly drops to zero: this change of momentum over a short period of time is the result of a strong force. The impulse-momentum theorem allows to estimate the average force applied by the wooden board to the hand, provided the duration of the collision  $\Delta t$  is known. For the third Newton's law, such a force is equal in magnitude to the force applied to the board by the hand. The time interval  $\Delta t$  depends on the wood elasticity and the hand velocity. To estimate its order of magnitude let's take the example of a hand hitting a 2 cm thick, 30 cm long dry white pine board with a velocity of  $\sim 10$  m/s: according to [3] the collision lasts about 4 ms. Assuming an effective mass of 4 kg for the hand (the whole arm is swinging, not only the hand), an average force of  $\sim 10,000$  N can be derived. Such a force, equivalent to the weight of a  $\sim 1,000$  kg object, is applied to a small area, for instance

<sup>51</sup> Vectors are in bold in all equations.

corresponding to the first two knuckles. The resulting stress is larger than the typical stress a wooden board can sustain and the board breaks.

#### **ADDITIONAL NOTES**

In conclusion, some additional remarks on wood in martial arts are mentioned here.

Taekwondo matches are played on mats that can be laid on supporting wooden platforms, i.e., made of a plywood plane fixed on to solid timber frames.

In some martial arts, such as in karate, wooden dummies are used for training. They are generally constituted by a cylindrical, vertical element from which various rods emerge, in a schematic representation of the opponent's body.

Finally, various martial arts envisage the use of wooden combat items: this is the case, to name but one, of the wooden sticks used in aikido.

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[1] [www.olympics.com](http://www.olympics.com) [accessed on 22 February 2022].

[2] [www.wood-database.com](http://www.wood-database.com) [accessed on 24 February 2022].

[3] [www.sciencedemonstrations.fas.harvard.edu/presentations/karate-blow](http://www.sciencedemonstrations.fas.harvard.edu/presentations/karate-blow) [accessed on 24 February 2022]