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A technical-pedagogical and historical reflection on the conceptual and biomechanical properties of *Kōdōkan jūdō's "ko-uchi-gari"* [minor inner reaping throw]

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Abstract

Throwing techniques represent an important part of *Kōdōkan jūdō*, aimed at defeating an opponent. *Ko-uchi-gari* [minor inner reaping throw] is a versatile throw of which the exact origin is unknown. Clear and correct *jūdō*-specific and didactic terminology are helpful in acquiring the complex motor skills that enable a refined and highly technical *jūdō*. *Ko-uchi-gari* relies on the physics principle of a "simple couple," i.e., an acting pair of two bound opposing forces around the opponent's center of mass with the result, in this case, being perpendicular to those forces, hence producing a torque. Appreciating this may provide an idea about the method this throwing technique is relying on to achieve its success and about its challenges. The purpose of the present paper is to improve the understanding of *ko-uchi-gari* from a historical, terminological, linguistic, technical, and biomechanical perspective in order to facilitate transferring or acquiring the motor skills necessary to properly master and teach this *jūdō* throwing technique.

Kōdōkan jūdō 講道館柔道¹ is a Japanese form of pedagogy, created by Kanō Jigorō 嘉納治五郎 (1860–1938),² based on neoconfucianist values and modern Western principles developed by John Dewey, John Stuart Mill, and Herbert Spencer (De Créé & Jones, 2009). Neoconfucianism is an ethical humanist philosophy and way of life that promotes traditional Confucianist virtues (etiquette, forgiveness, filial piety, honesty, humaneness, integrity, knowledge, loyalty, modesty, respectfulness, and righteousness), while arguing that knowledge is intuitive and not rational. Neoconfucianism formed the philosophic framework of *bushidō*, the Japanese code of chivalry among the samurai. Dewey, Stuart Mill, and Spencer were influential 19th-century progressive philosophers and political theorists, characterized by a liberal pragmatism, utilitarianism, and empiricism. Furthermore, Dewey is particularly known as a leading American progressive educational reformer.

Jūdō's practical study consists of *randori* 乱取 (free exercises) and 10 different (*Kōdōkan*) *kata* 形 (predetermined and choreographed physical exercises). The building stones of *randori* and *kata* are *nage-waza* 投技 (throwing techniques) and *katame-waza* 固技 (control techniques; Kanō, 1930a, 1930b, 1930c). In addition to its pedagogical and philosophical foundations, *jūdō* contains a major physical education component that was derived from several Japanese Medieval unarmed combat schools, known as *jūjutsu ryūha* 柔術流派. In this way, *jūdō* attempts to realize its triple objective of: *shūshin-hō* 修身法 (moral training), *rentai-hō* 練体法 (physical education), and *shōbu-hō* 尚武法 (martial art; Kanō, 1931, 2006; De Créé, 2012).

In *jūdō*, only selected *jūjutsu* techniques are used, often refined or modified for safe-

¹For absolute rigor, long Japanese vowel sounds have been approximated using macrons (e.g., *Kōdōkan*) in order to indicate their Japanese pronunciation as closely as possible. However, when referring to or quoting from Western literature, the relevant text or author is cited exactly as per the original source, with macrons used or omitted accordingly.

²Japanese names in this paper are listed by family name first and given name second, as common in traditional Japanese usage and to maintain consistency with the order of names of Japanese historic figures.

ty and modern practicality. Over the last 70 years, the practical physical education component of *jūdō* has evolved into an Olympic competitive sport. The goals of the sport of *jūdō* are somewhat different from the more comprehensive goals of *jūdō* as a pedagogical method. In sports *jūdō*, the aim is merely to win through scoring points. Points are awarded for a successful throwing technique, for immobilizing and pinning the opponent with both shoulders on the mat for a certain amount of time, or for submitting the opponent through an armbar or choke. The person who performs the throw or technique is often referred to as *tori*, whereas the person who is being thrown, pinned, armbarred, or choked is often referred to as *uke*.

The evolution of the sports component of *jūdō* has caused many techniques to be added to its curriculum, either newly developed or imported from other combat sports, in order to add potential advantages to the competitors' scoring chances. Nevertheless, within its teaching system, the classical techniques developed or approved by Kanō Jigorō represent the majority of practical material that needs to be mastered in order to develop proficiency in the physical application of *jūdō*. In addition, understanding the principles of those techniques is instrumental to fully capture how mastering practical *jūdō* is underpinned by its maxims of *Sei-ryoku saizen katsuyō* 精力最善活用 [Optimal use of energy] (usually abbreviated to *Sei-ryoku zenyō* 精力善用) and *Jū yoku gō (w) o sei suru* 柔能く剛を精する [Non-resistance overcomes force] (Kanō, 2006). A classical throwing technique within *Kōdōkan jūdō* that illustrates these principles is *ko-uchi-gari* 小内刈 or "minor inner reaping throw."

Acquiring the motor skills that enable a refined and highly technical *jūdō* is a long and hard road. Clear and correct communication in *jūdō*-specific and didactic terminology is helpful in accomplishing this process. Terminology and categorization of a *jūdō* throw may provide an idea about the method a technique is relying on to achieve its success and about the challenges it might present to the student. Such terminology and categorization can follow several approaches based on either systematic or personalized didactic views within one's own cultural framework, but also on physics and biomechanics. As our understanding of physics and biomechanics has evolved since the creation of *Kōdōkan jūdō* in 1882, the question arises whether present day understanding of science has something to offer that may warrant a revision of *jūdō* terminology or categorization of *jūdō* throws for pedagogical reasons. The present paper offers an overview of *ko-uchi-gari*'s place and evolution of its categorization among *jūdō* throws, with an emphasis on its technical and biomechanical properties and challenges. The purpose of this paper is to improve the appreciation and understanding of *ko-uchi-*

gari from a historical, terminological, linguistic, technical, and biomechanical viewpoint in order to facilitate transferring or acquiring the skill necessary to properly master and teach this *jūdō* throwing technique.

Origin of *ko-uchi-gari*

The exact origin of *ko-uchi-gari* is unknown (Daigo, 2005). It does not figure in either of *jūdō*'s two parent schools, *Kitō-ryū jūjutsu* 起倒流柔術 and *Tenjin shinyō-ryū jūjutsu* 天神真楊流柔術. *Kōdōkan jūdō* has adopted several other throwing techniques from *Tenjin shinyō-ryū jūjutsu*, such as, notably: *ō-soto-gari* 大外刈 (under the name of *mata-futsu* 股拂 [thigh sweep]) and *ko-soto-gake* 小外掛け or *ashi-barai* 足拂 [leg sweep] (under the name of *sukui-ashi* すくい足 [leg spoon]; De Créé, 2012). The technique also does not come from the *Totsuka-ha Yoshin-ryū* 戸塚派揚心流 or from *sumō* 相撲, from which different throwing techniques were incorporated into *Kōdōkan jūdō* (Bennett, 2009, p. 50). However, there exists a technique called *uchi kurobushi harai*³ 内踝払 [sweeping with the inner side of the ankle] which is part of the curriculum in some *koryū* 古流 [traditional martial arts] schools, and which is the likeliest source of *Kōdōkan jūdō*'s *ko-uchi-gari*.

Ko-uchi-gari is not separately described in the very first *jūdō* books in Japanese such as those by Uchida Ryōhei and Arima Sumitomo, which date from 1903 and 1904, respectively, and which only describe a few selected techniques. However, it is included in the first *jūdō* books in Western languages, such as Arima Sumitomo's 有馬純臣 1906 book in English, and Sasaki Kichisaburō's 佐々木吉三郎 book in Hungarian (Sasaki, 1907; see Fig. 1). It is also included in Yokoyama Sakujirō 横山作次郎 and Ōshima Eisuke's 大島英助 1908 book (in Japanese), as well as in its 1911 French translation by Yves Le Prieur (Yokoyama & Ōshima, 1911). Thus, the technique clearly existed much earlier as it is described being used at the *Kōdōkan* in a *Kōhaku-shiai* 紅白試合 [Red and White promotion tournament] in 1890 by Hirose Takeo 広瀬武夫 (1868–1904) (Bennett, 2009, p. 53).

Definition and description of *ko-uchi-gari*

Mifune Kyūzō 三船久蔵, *Kōdōkan* 10th *dan* (1888–1965), defines the idea behind *ko-uchi-gari* as follows: "This technique is to reap your opponent's right foot with your right foot or his left foot with your left foot bending like the sickle" (Mifune, 1956, p. 63).

Mifune further describes the technique: "Just when his right foot advances and some weight of his body is set on his foot, you must reap from inside promptly the upper part of his right heel with your right foot bending like the sickle. Simultaneously, make him fall with both

³Kurobushi 踝 is also a medical pressure point that, according to some old *jūjutsu* schools, is the most painful on the body and even lethal if properly manipulated.



Fig. 1. *Ko-uchi-gari* [minor inner reaping throw] as it appeared in 1907 in the Budapest-published book by Sasaki Kichisaburō (Sasaki, 2007, p. 85).

hands pushing him instantly towards the right corner” (Mifune, 1956, p. 63).

In the *Kōdōkan* system, a large number of leg-throws rely on one of three seemingly similar, yet different, ways of making the opponent fall by taking away his leg of support. These three ways are: *harau-waza* 払う技 [sweeping techniques], *kari-waza* 刈技 [reaping techniques], and *kake-waza* 掛技 [hooking techniques]. Reaping techniques are distinctively different from sweeping techniques and hooking techniques in so far as the *uke* (the person being thrown) has more of his body mass leaning on the foot which is attacked, than in a *harai* movement (where the *uke's* mass is still mostly on the non-attacked foot), and less than in *gake* movement (typically *uke's* full mass is supported by the attacked foot). However, both Mifune and the *Kōdōkan* waive that distinction when the throw attacks the interior of the leg/foot. Accordingly, Mifune further elaborates on one of the forms of *ko-uchi-gari*: “Again you can reap the opponent in the right self-defense posture, although somewhat abnormal in this form. In this, you reap the popliteal region of his leg from the inner side with the back of your ankle, and pull him down towards the right back corner” (Mifune, 1956, p. 63).

In performing *ko-uchi-gari*, the continuation of the

lever movement to the back is essential to maintain proper control, even when the reaping foot may already be fully engaged in a rotational motion in the sagittal plane: “This is not different in purport from the case of minor exterior reap, but it is by this technique that you push down the opponent towards the rear corner with relative strength, and you must add carefully and promptly the strength of both your hands to push-down motion” (Mifune, 1956, p. 64).

In fact, Mifune explicitly warns against failing to maintain this control: “Forgetting to reap and pull the foot sole promptly, you are sometimes apt to sweep it up. In this case, you may be thrown by the opponent’s techniques such as *Hizaguruma* (knee-wheeling), *Saetsurikomi* or *Tomoe-nage* utilizing your foot believing to have scooped it up” (Mifune, 1956, p. 64).

Kawaishi Mikinosuke 川石酒造之助 (1899-1969), in his own words, describes *ko-uchi-gari* in a very similar way (see Fig. 2):

Uke stands with his feet spread on one line, or with the right foot forward. *Tori* quickly steps forward with his left

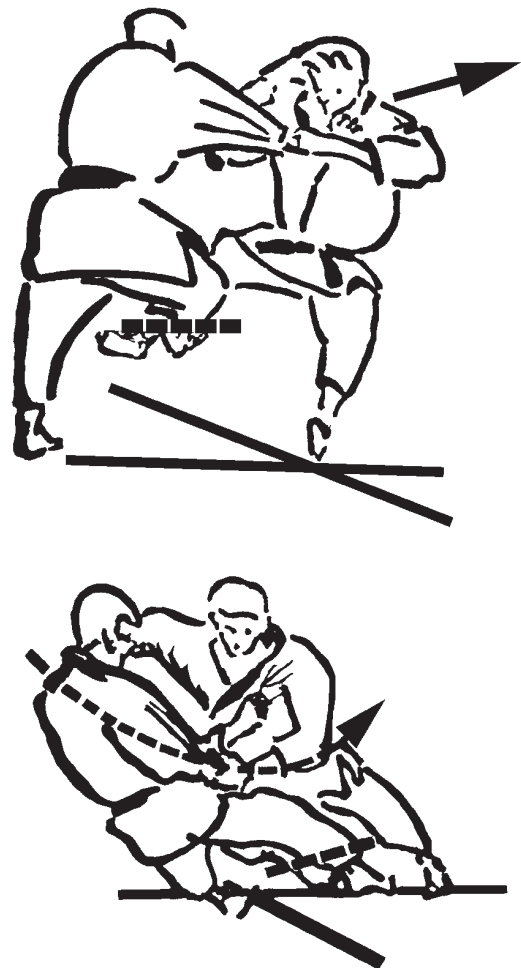


Fig. 2. *Ko-uchi-gari* [minor inner reaping throw] as considered by Kawaishi (1951, p. 36).

foot; he thus supports his body weight with his left leg. At the same moment, he brings the sole of his right foot as a hook behind *uke's* right foot and horizontally pursues *uke's* foot in the direction of his toes. At the same time, he very quickly and forcefully pushes with both arms straight, his fists as a "clothes hanger" slightly lifting *uke* to avoid letting him regain his balance. Essential, for *tori*, is to make these movements fast and simultaneously, and to sufficiently have advanced his left leg in order to be able to then pursue *uke* as far as possible without having to make an extra step.

Note: "Tori's push establishes the imbalance, but *tori* at the end of the movement [also] can proceed by completing a rotation to the left" (Translated from Kawaiishi, 1951, p. 36).

The traditional Kōdōkan jūdō throwing technique classifications

Yokoyama and Ōshima suggest that *Kōdōkan jūdō's Nage-waza* 投技 [throwing techniques], at one point (pre-1895), initially may have been grouped into three main categories: *Taosu koto* 倒す事 [Throw down techniques], *Otosu koto* 落とす事 [Drop techniques], and *Uchi tsukeru* 打付ける [Hit and strike techniques] (Yokoyama & Ōshima, 1911, p. 9). The development of throwing techniques in *Kōdōkan jūdō* is detailed elsewhere (Maruyama, 1939; Kanō-sensei Denki Hensankai, 1984).

The *Kōdōkan* further classifies *jūdō's* throws either in one of the three groups of *Tachi-waza* 立ち技 or Standing Techniques: 1. *Te-waza* 手技 [Hand Techniques], 2. *Koshi-waza* 腰技 [Hip Techniques], and 3. *Ashi-waza* 足技 [Leg Techniques], or in one of the two groups of *Sutemi-waza* 捨身技 or Sacrifice Techniques: 1. *Ma-sutemi-waza* 真捨身技 [True (Back) Sacrifice Techniques] and 2. *Yoko-sutemi-waza* 横捨身技 [Side Sacrifice Techniques] (Kōdōkan, 1986; Magara, 1992; Kanō, Kawamura, Nakamura, Daigo, Takeuchi, & Satō, 1999). This categorization was largely based on the body part (hand, foot or leg, hip) or body position (standing vs lying down), which was considered most critical to the execution or *kake* 掛 phase of the throw. *Ko-uchi-gari*, accordingly, was ranked as an *Ashi-waza* type of technique, since it was perceived that it was the leg movement which was dominant for this technique. This classification was already in place by 1889, as is unambiguously evidenced by Kanō-*shihan* detailing it that year in a lecture held at the *Dai Nihon Kyōikukai* 大日本教育会 [Greater Japan Society of Education] (Watanabe, 1971).

In 1895, *Kōdōkan jūdō's nage-waza* became structured in the *Gokyō no waza* 五教の技, consisting of 42 techniques divided over five groups of learning (7 + 7 + 7 + 10 + 11), categorized according to progressive difficulty in executing proper *Ukemi* 受身 or breakfalls to safely undergo those techniques (Kanō, 1931; Kōdōkan, 1986). In that original 1895 *Gokyō-no-waza* classification, *ko-uchi-gari* was the fourth technique of the fifth and last group

(Maruyama, 1939; Oimatsu, 1976; Kōdōkan, 1986; Kanō, *et al.*, 1999). This is rather interesting, knowing that, for example, *ura-nage* 裏投, generally considered as one of the more difficult or at least "harder" techniques to fall and throw with, was included in Group 3.

However, in the revised 1920 *Gokyō no waza* version, which consisted of a total of 40 throws (five groups of eight techniques), this was corrected, and *ko-uchi-gari* became the second throw of the *Dai nikyō* 第二教 or Second Group (Kōdōkan, 1986; Kanō, *et al.*, 1999). As with many other *jūdō* throws, the *ko-uchi-gari* principle knows a number of different expressions or variations (*henka* 変化). It is interesting to note that one of its effective variations is sometimes also referred to using erroneous terminology and called "*ko-uchi-makikomi*" 小内巻込. No throw under this name has ever existed in *Kōdōkan jūdō*, and accordingly, was not included in the *Gokyō* or any of the two appended groups of techniques (the eight *Habukareta-no-waza* 省るかれたの技 [Techniques preserved ... from the old 1895 version of the *Gokyō* ...] and 17 *Shinmeishō-no-waza* 新称の技 [newly named techniques]).

Mifune Kyūzō 三船久蔵 (1888–1965), in his 1956 *Canon of jūdō* (Mifune, 1956), and at that time chief instructor at the *Kōdōkan*, organized *jūdō's* throws according to five principles that deviated somewhat from Kanō Jigorō's classical *Gokyō* classification, although each "Principle" equally contained eight throws thus totaling 40 throws, a number which was identical to Kanō's 1920 *Gokyō no waza* system. In Mifune's system, *ko-uchi-gari* was included as the first throw of the Second Principle (Mifune, 1956). Most unfortunately, Mifune did not elaborate as to exactly what constitutes the philosophy and pedagogy behind his "Principles." One can speculate that he was contemplating a third revision of the *Gokyō* without touching the actual choice of throws made by Kanō, since the 40 throws in Mifune's Five Principles were identical to those included in the 1920 *Gokyō*, though they are in a different order.

Ko-uchi-gari's appearance in Kōdōkan and non-Kōdōkan-approved jūdō kata

Ko-uchi-gari was not included as a technique in any of the ten *Kōdōkan kata*. However, it was included in the three Japanese non-*Kōdōkan*-approved *jūdō kata*, as follows:

Go-no-sen-no-kata 後の前の形 [Forms of post-initiative response techniques]: Technique No. 6: *ko-uchi-gari* > < *sasae-tsuri-komi-ashi* 支釣り込み足

Kaeshi-no-kata 返の形 [Forms of counters]: Technique No. 3: *ko-uchi-gari* > < *okuri-ashi-barai* 送り足払い

Nage-waza-ura-no-kata 投技裏の形 [Forms of reverse throwing techniques]: Series No. 2, Technique No. 2 (= 7th technique) *ko-uchi-gari* > < *hiza-guruma* (hidari) 左膝車

In addition, it was included in several Western-developed non-*Kōdōkan*-approved *jūdō kata*:

Renraku-no-kata 連絡の形 [Forms of continuation]: Technique No. 14: *yoko-guruma* 横車 + *ko-uchi-makikomi* 小内巻込 (= *ko-uchi-gari*)

Rensa-no-kata 連鎖の形 [Forms of chain-techniques]: Series No. 2, Technique No. 2: *ko-uchi-gake* 小内掛 (= *ko-uchi-gari*) + *ryōte-jime* 両手絞 & Technique No. 4: *ko-uchi-gari* + *kata-ha-jime* 片羽絞; Series No. 3, Technique No. 2: *ko-uchi-gari* + *ashi-gatame* 脚固 & Technique No. 3: *ko-uchi-barai* 小内払 (= *ko-uchi-gari*) + *gyaku-waki-gatame* 逆腋固 (Steidele, 1999)

Hōhō-kata 方法形 [Forms of methodology]: Technique No. 5: *ko-uchi-gari* (Hofmann, 1977)

Shintai-kōki-no-kata 進退好機の形 [Forms of opportunities of movement]: Series No. 1, Technique No. 2: *ko-uchi-gari* (Giral-di, 1975)

This implies three appearances in three Japanese non-Kōdōkan-approved *kata*, and six appearances in four Western non-Kōdōkan-approved *jūdō kata*. We note that of these nine appearances of *ko-uchi-gari* in total, eight appearances are as a combination or a counter throw. This is not a coincidence and illustrates *ko-uchi-gari*'s unique suitability for this purpose. Certainly, this is relevant when considering its technical properties or its biomechanical foundation. However, by no means do we suggest that *ko-uchi-gari* would be less suited as a stand-alone throw.

Non-Kōdōkan historical classifications of *jūdō* throwing techniques

Probably the most well-known classification of *jūdō* throws different to that of the *Kōdōkan*, is the one by Kawaishi Mikinosuke 河石幹之助 (1899–1970) in France. Kawaishi's *jūdō* pedagogical system was influential in France, and in the late 1940s and 1950s also in Belgium, The Netherlands, and Germany. He is probably most known in Europe and other countries for his introduction of the color belt system for *kyū* 級 ranks as an alternative to the *Kōdōkan*, which only used the colors white and brown to indicate every *kyū* rank from 6th up to 1st. Kawaishi's seminal book, *Ma méthode de judo* [My method of *jūdō*], dates from 1951 and detailed his classification system, which attempted to circumvent potential difficulties for foreign *jūdōka* unfamiliar with the relatively large vocabulary of Japanese terms used in *jūdō*; hence, Kawaishi, as an alternative, produced a system based on numbers. The other most noticeable difference with the *Kōdōkan* system is that Kawaishi's system included an extra category of standing throws, in that he splits the *Kōdōkan*'s *Te-waza* into two separate categories, namely Shoulder Throws and Hand Throws (Kawaishi, 1951). In his system, *ko-uchi-gari* is the *Sixième lancement de jambe* or "6th Leg Throw." There are 15 numbered leg throws in his classification of *jūdō* throws. Kawaishi's system also recognizes 15 hip throws, six shoulder throws, nine arm throws, and 15 sacrifice throws which he does not further divide (Kawaishi, 1951).

In Great Britain, Koizumi Gunji 小泉軍司 (1885–1965), the founder of the *Budōkwai* and a founding

member of the *British Judo Association* (BJA), devised his own classification in which he split *jūdō* throwing techniques into three categories: *Kuruma-waza* 車技 [Wheel Techniques], *Tenbin-waza* 天秤 [Balance Techniques], and *Tsumazukase-waza* 躓かせ技 [Tripping Techniques] (Koizumi, 1960). He included *ko-uchi-gari* in the *Tsumazukase-waza* since he felt the key to the technique was tripping *uke*'s 受 ["He who undergoes"] foot and thus preventing him/her from continuing his movement and regaining stability.

However, in 1970 Fujiwara Toyosaburō 藤原豊三郎 (biographical data unknown) introduced three alternative categories to distinguish *jūdō* throws (Fujiwara, Uchida, & Wilson, 1970). These groups consisted of *Ateru-waza* 当てる技 [Placing Techniques], *Karu-waza* 刈る技 [Reaping Techniques], and *Harau-waza* 払う技 [Sweeping Techniques] (Sacripanti, 2010). In this system, *ko-uchi-gari* was listed as a reaping technique. Later classifications, such as that suggested by Tavolucci in 1993, supported classifying *ko-uchi-gari* as a *Kari-waza* 刈技 or reaping technique, as Geesink had already done in 1967 (Geesink, 1967, 2000; Sacripanti, 2010).

Recent classification systems of *jūdō* throws

In 1984, Gleeson attempted to classify *jūdō* throws according to *uke*'s movement while under *tori*'s 取 ["the person who is doing the throwing"] control (Gleeson, 1984). The three main groups Gleeson created were "Lifting Techniques," "Rotating Techniques," and "Trick Techniques." Rotating Techniques were then subdivided into "Pure Rotation" and "Transport Techniques." *Ko-uchi-gari*, in the Gleeson system, was categorized as a "Rotating (Transport) Technique" in recognition of the forward movement which the *uke* makes when being thrown prior to rotation (Sacripanti, 2010).

Adams attempted to organize throws based on the contest situation in 1992 (Sacripanti, 2010). He suggested that *ko-uchi-gari* was most effectively employed as a backward throw inside the *uke*'s arms. Unlike the *jūdō* throws classification systems introduced by Kawaishi and Koizumi, neither the Gleeson nor the Adams system seem to have been incorporated by many followers among the *jūdō* population, or other authors for that matter. One might speculate that a major reason is that these alternative systems are not perceived to offer tangible advantages either in the progression of the average *jūdō* student, or in the competitive success of the elite player. Thus, the principles underpinning the execution of *ko-uchi-gari* seemed to have reached a degree of consensus in terms of focus and emphasis.

One of the most interesting classifications, though, was proposed by Dr. Ashida Sachio 芦田幸男 (1924–2009) in 1995. Ashida, later *Kōdōkan* 8th *dan* and *United States Jūdō Federation* (USJF) 9th *dan*, was a professor of psychology who had emigrated from Japan. He sug-

gested a simple classification of *jūdō* throws based on the direction of the force vector. His system used just two subdivisions: 1. Lift and thrust, and 2. Lift and wind (Sacripanti, 2010). In the first category, the *tori* has to significantly overcome his adversary's defense resulting from the combination of body mass and shifting of balance and reactions (e.g., *ō-soto-gari* 大外刈 [major outer reaping throw], *ō-uchi-gari* 大内刈 [major inner reaping throw]). In the second group, Ashida suggests that some techniques (e.g., *seoi-nage* 背負投 [Back/shoulder carrying throw], *uchi-mata* 内股 [inner thigh throw]), however, achieve their effect through partly or chiefly relying on centripetal force and the conservation of angular momentum (Sacripanti, 2010). Ashida's classification, from a biomechanical point of view, was interesting because unlike several of the previous classifications, it mainly relied on an understanding of the throws' biomechanical foundation.

Yiannakis (2011) proposed that *jūdō* techniques are built from combinations of structural elements and operational principles in a variety of configurations and directions, as well as contextual principles. However, rather than a useful or practical classification to categorize or discriminate between throws and their underlying mechanisms, her terminology represented a more generalized description of a set of pointers, of which some, but oftentimes not all, may play a role in a specific technique, and which an instructor might consider when supervising a particular individual. As far as classification of throwing techniques is concerned, Yiannakis (2011) adopted the *Kōdōkan's Gokyō* system.

The biomechanical classification of *ko-uchi-gari*

Attilio Sacripanti (born 1947), an Italian physicist and biomechanics professor, devised the first comprehensive scientific biomechanical classification of *jūdō* techniques in 1987 (Sacripanti, 1987, 1997, 2010, 2011). Through the utilization of biomechanical principles, he concluded that throws could be classified in two groups. The groups he devised were what he called "Physical Lever" and "Couple of Forces" (Monti & Sacripanti, 1995; Sacripanti, 2010, 2011). Physical Lever techniques were those techniques where a force was applied with the arms against a fulcrum to complete the throw (Sacripanti, 1997, 2010, 2011). Physical Lever techniques were further subdivided into the divisions of Minimum Arm, Medium Arm, Maximum Arm, and Variable Arm. The relative height of the fulcrum created for the throw determines the arm-lever group it should be classified into. The higher the fulcrum on *uke's* body, the less arm force is required to execute such a throw effectively (Sacripanti, 2010, 2011).

With regard to "Couple of Forces" throws, a "couple" in mechanics is "a set of bound vectors whose resultant is equal to zero" (Kane & Levinson, 1985, p. 94).

However, this resultant is equal to zero only if it lies in the same plane as those forces. If, on the other hand, the resultant is perpendicular to the direction of the forces, then the resultant is not zero, but a torque. Furthermore, "a couple consisting of only two vectors is called a 'simple couple.' Hence the vectors forming a simple couple necessarily have equal magnitudes and opposite directions." (Kane & Levinson, 1985, p. 94). The moment of the couple around a point is the torque of the couple, and is unique in a sense that "a couple has the same moment about all points" (Kane & Levinson, 1985, p. 94). Sacripanti uses the term *Couple of Forces* to indicate such a set of bound vectors that represent the acting pair of two opposing forces around the center of mass, with the resultant force being perpendicular to those forces and thus producing a torque. Thus, in the case of *jūdō* throws, this grouping was based around techniques where two opposing forces were applied to perform the throw.

"Couple of Forces" techniques were also further subdivided into:

- Arms
- Arm(s) and Leg
- Trunk and Legs
- Trunk and Arms
- Legs

Ko-uchi-gari was classified as a "Couple of Forces, Arm(s) and Leg technique" (Fig. 3). *Ko-uchi-gari* requires a clear opposing set of forces provided by the *Tori's* arms driving the *Uke* to his rear corner and *Tori's* foot reaping *Uke's* foot in the opposite direction, thus forwards (Sacripanti, 2010, 2011).



Fig. 3. The set of bound vectors about the center of mass, which represents the mechanical "couple" active during *ko-uchi-gari*, is shown by both arrows pointing in opposite directions their middle point being the center of mass. From Sacripanti, 2010, by permission.

Sacripanti further determined that, for the purpose of teaching, the forces acting in *jūdō* throws could be described within the body's three biomechanical planes of symmetry: the sagittal, frontal, and transversal plane. In *ko-uchi-gari*, as such, the forces operate in the transversal plane. The *tori*, who is applying the "couple of forces," or more specifically, the "simple couple," thus moves in the sagittal plane. At the same time, the movement incorporates a rotation around the vertical axis involving the trunk/leg compartment which encompasses the coxo-femoral articulation. These two concomitant actions highlight the flexibility the *tori* needs in order to perform *ko-uchi-gari* effectively.

Major points of attention in *ko-uchi-gari*

From the above technical descriptions by Mifune and Kawaishi, respectively, it is clear that emphasis should be devoted to executing the *ko-uchi-gari* movement with sufficient speed and promptness, with sufficient control to maintain *uke's* imbalance, and with attention to reaping in the direction of *uke's* toes.

Often though, when *ko-uchi-gari* is taught in *jūdō* clubs or during clinics, one or two important points may be highlighted, but several others are ignored or not fully understood. While reviewing *ko-uchi-gari* as part of the first ever international *jūdō* coaching qualification course, i.e., the first European Jūdō Union [EJU] Level 6 Coaching Award course and the inaugural class of the University of Rome's Master's Degree in Teaching and Coaching Jūdō, students (14 black belts with prior advanced instructor and coach credentials and having been internationally recruited) were asked about important technical points for *ko-uchi-gari*. The responses and suggestions they gave, placed emphasis mostly on pushing with both arms, but did not fully consider some other crucial points. If the frequent errors (as observed by the authors during both national and international club visits, clinics, seminars, and competition) made by *jūdōka* when practicing and attempting *ko-uchi-gari*, and by coaches and instructors while teaching this technique, accurately reflect how this throw is frequently understood, then these responses reflect that its principles and important points are only partly appreciated. Even Mifune's and Kawaishi's descriptions of the technique do not fully tell the story as they largely focus on the *kake* or execution phase, but not on the preparatory work or what precedes in order to properly perform this technique in agreement with Kanō's maxims of maximal efficiency at minimal effort and overcoming strength with yielding.

The *Kōdōkan*, as well as most popular books on *jūdō*, typically teach that a *jūdō* throw consists of three phases, in the following order: 1. *tsukuri* 作り [preparation], 2. *kuzushi* 崩し [unbalancing], and 3. *kake* 掛け [execution] (*Kōdōkan*, 1986, pp. 42-44). Thus, at the most,

these three objectives are the focus of technical attention by teachers and *jūdō* books, while a common error in learning *jūdō* throws often involves one or more of these objectives being ignored or forgotten. Another question is also whether these three objectives, as commonly mentioned within *Kōdōkan* sources, adequately and comprehensively establish the essence of *jūdō* throws.

Hirano Tokio 平野時男 (1922-1993) argued that a *jūdō* throw, in fact, has four phases, most commonly: 1. *kumu* 組む [gripping], 2. *tsukuri* 作り [preparation], 3. *kake* 掛け [execution], and *nageru* 投げる [throwing], and No. 1 and No. 2 should be reversed, thus *tsukuri* preceding *kumu* (Chen & Chen, 2002). Observations of contest *jūdō* at the Olympic, world, and continental championship levels over the last two decades show that the majority of *jūdōka* in modern times strongly adhere to a preferred or personalized grip which they attempt to establish in every fight and which is aimed at controlling the opponent and at representing the starting point of any eventual action. Contemporary competition-oriented textbooks of *jūdō* and many seminars often favor this approach (Adams, 1992). Hirano, however, offers a diametrically opposed view emphasizing that gripping should not be predetermined and used to start off with or "set up" a technique. Instead, gripping should be the logical consequence (following Kanō's maxims) after *tsukuri*, with that *tsukuri* action simply representing what the opponent is doing. Hirano usually does not distinguish a separate *kuzushi* phase, since the opponent, as a result of his own movements, will always have a relative imbalance somewhere, which the ensuing choice of gripping then will simply reinforce. This also has implications on how to perform *ko-uchi-gari*, in particular in recognizing when *uke* completes what is sufficient to reach a suitable position in which *ko-uchi-gari* is the proper choice (Hirano, 1969).

According to De Créé (2012), while accepting Hirano's reversal of *tsukuri* preceding *kumu*, the three stages provided by either the *Kōdōkan* or Hirano still do not fully capture all essential technical parts of a proper *jūdō* throw. Consequently, De Créé recognizes seven phases:

1. Debana 出端 [The opportunity and optimal moment to succeed]
2. *tsukuri* 作り [Preparation]
3. *kumu* 組む [Gripping]
4. *kuzushi* 崩し [Unbalancing]
5. *kake* 掛け [Execution]
6. *nageru* 投げる [Throwing]
7. *Zanshin* 残心 [The follow through, literally, the "continuation of the spirit"]

The order of Phases 1 through 4 may change depending on the specific circumstance. These seven phases are *jūdō*-technical, *jūdō*-motor skills, and *jūdō*-philosophy and -pedagogy. They are neither physical nor biomechanical principles. There are clearly different physical principles that apply to the *tsukuri*/*ku-*

zushi (i.e., so-called “action invariants” that build on the Hamilton-Lagrange equation and Hamilton Action Principle) and to the *kake* (lever techniques vs “couple of forces” techniques) phases (Sacripanti, 2010). Yet, all seven phases detailed above are important in a pedagogical and skills-acquisition sense. For example, even if completely mastering the unbalancing that needs to precede execution of a throwing technique, this will fail to reach the desired result if one does not fully grasp what precisely is and how to discern *de-bana* or the proper moment and opportunity to apply that unbalancing. Similarly, if you do not master *zanshin*, you might be able to throw the opponent, followed up by your opponent choking you out hence effectively securing his win over you. However, in terms of pure physics and biomechanics, it is virtually impossible to distinguish so many different phases as they flow into each other as a single movement, allowing, at the most, three phases in which distinctive physical principles may occur, precisely as described by Sacripanti (Sacripanti, 1997, 2010, 2011). Thus, from a mechanical point of view it would not be helpful to distinguish as many as seven different phases. These reflections on the pedagogical and skills acquisition issues fit well with the analytical understanding that in order to produce a lever action in agreement with the principles of *jūdō*, it is beneficial to find an ideal opportunity that maximizes unbalance with the least possible effort. However, whether very little or very much effort, the physics and mechanical principles remain generally identical though only the action requiring the least effort truly represents the spirit of *jūdō* and that which the *jūdōka* ideally needs to be striving for. It is thus not merely a matter of succeeding in placing a throw, but also how that throw is achieved.



Fig. 4. Legendary *jūdō* champion Okano Isao 岡野功 (born 1944), shown here executing a powerful *ko-uchi-gari*, during the 1964 Tōkyō Olympics on his way to the gold medal. The driving force of the arms and reaping action of the foot are clearly visualized here.

The meaning in Japanese of the word *Zanshin*, as it is used in *budō*, technically is a philosophical phase, which follows the execution though it is certainly not a follow-up technique. The term is most apt explained in *kyūdō* 弓道 [archery] and the various arts of the sword (*iaijutsu* 居合術, *iaidō* 居合道, *kenjutsu* 剣術, *kendō* 剣道). However, *zanshin* manifests itself in continuing control of the *uke*, after he has hit the mat. “Continuing control,” in this sense, does not imply following up with *katame-waza* 固技 [holding techniques], but being in control of one’s *ki* 気 [spirit], one’s self, and the opponent. The term *zanshin* is not frequently heard in *jūdō*, and some, for example in the *Kōdōkan*, have even argued that *zan-*



Fig. 5. Okano Isao-sensei 岡野功 (born 1944), here during a *jūdō* seminar, explains the importance of *tori*'s pushing action being initiated and remaining in the sagittal plane. It is crucial that during the preparation phase, *uke* [“the person being thrown”] is brought on his heels, and kept on his heels with control. To get *uke* in that position is ideally done by applying Newton’s Third Law of action/reaction, and provoke *uke* by pulling him, so that he reacts by resisting toward the back. Depending on *uke*'s *jūdō* skills, reactions, way of moving, and relative control, this may not always be possible; in such case, “pushing” *uke* on his heels offers an alternative, although less elegant, and less in respect of Kanō’s maxims. Direction of pushing is as illustrated in Fig. 3. Demonstrating here is Okano Isao-sensei 岡野功 (born 1944); *uke* is Okano-sensei’s son Okano Tetsuo. Picture taken August 31, 2008.



Fig. 6. Equally crucial is to maintain control (pushing action toward the ground behind *uke's* ["the person being thrown"] right shoulder), and to push the *hara* 腹 [belly] toward the *tatami*. This is one of the most common mistakes, even by *jūdō* instructors and well-known champions. Control should not end at the beginning point of the reaping and *uke* starting to fall, but should be maintained throughout the final point of *zanshin* 残心 [the "follow through"]. Demonstrating here is Okano Isao-sensei 岡野功 (born 1944); *uke* is Okano-sensei's son Okano Tetsuo. Picture taken August 31, 2008.

shin does not exist in *Kōdōkan jūdō*. That is, however, not quite true. The parent school of *jūdō* that provides the major philosophical foundation for *Kōdōkan jūdō's* throwing techniques, is *Kitō-ryū jūjutsu* 起倒流柔術. Every throw of the *Omote-kata* 表形 series of *Kitō-ryū's Yoroi kumi-uchi-no-kata* 鎧組打の形, nearly integrally exported by *Kanō-shihan* into *jūdō* as *Koshiki-no-kata* 古式の形 [The Antique Forms], ends in and emphasizes *zanshin*, in this case, strongly tied in with the position *Kurai-dori* 位取 (the seated safety position in which the *tori* must have reached great awareness and alertness of his surroundings while maintaining the utmost calm and a dissolution of the Self).

The term *zanshin* 残心, when split up in its components, literally means "the remaining mind," although the compound term is more correctly translated as "the continuation of the spirit." In the biomechanical explanation of *jūdō* throws, Sacripanti uses the term as "the follow through," which is indeed also a correct translation of the Japanese word *zanshin*, but the term "follow through" in the biomechanical sense is explained in an entirely different way and implies a "follow-up," that is to say, the necessary control over *uke's* "body flight" in such a way that if no *ippon* [one full point] is scored, would allow an ensuing control technique. Thus, from the biomechanical or physical point of view when considering a *jūdō* throw, the throw (the original technique) at that point has already been carried out, but a second technique may be applied to follow up. However, that is not entirely what *zanshin* means in Japanese or in its use in *budō* including *jūdō*. *Zanshin* is an integral part of one, thus each and every single throwing technique. Admittedly, there is a shift in level of discourse when *zanshin* is used to emphasize the purpose (i.e., a higher level of purpose which the technique should express) rather than the actual follow-up technique.

The continuation of control should require more attention in teaching of throws, and thus also with regard to *ko-uchi-gari*. Furthermore, in achieving proper *ku-zushi*, *nageru*, and *zanshin*, correct use of the *hara* 腹 [belly] and *tanden* 丹田 (the philosophical focus point below the navel which is considered critical as a center of energy in Japanese and Oriental philosophies and *budō*) is essential. So, is the proper use of Newton's Third Law (action vs reaction), in order to apply the underlying biomechanical lever principles in such a way that they are realized with minimal effort and while maximally yielding.

To teach or evaluate *ko-uchi-gari* correctly requires extraordinary *jūdō* skills and understanding. One person possessing total mastery of this technique and those skills, is Okano Isao 岡野功 (born 1944), the legendary Tōkyō Olympics 1964 Middle-weight winner, 1965 World Champion, and only middle-weight *jūdōka* to have won the no-weight class post-World War II All Japan Championships twice (Fig. 4).

Thus, the illustrative material (Figs. 5–9) presented

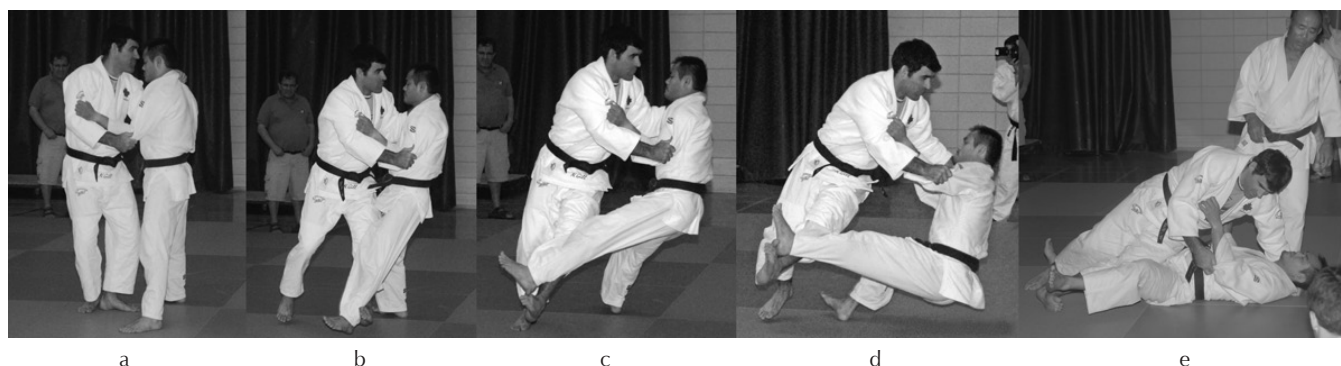


Fig. 7. Multiple Canadian national champion and Sydney Olympics 100-kg silver medalist *jūdō* Nicholas Gill demonstrates *ko-uchi-gari*, in response to Okano-sensei's request. Gill is a very good technician with an impressive competition record. Yet, his *ko-uchi-gari*, as shown, still has room for improvement. This demonstrates the point raised earlier in this paper, that many, and arguably most, top athletes and champions, including the most skillful among them, still have major errors in their techniques. In this case, the error is two-fold. Figure 7d shows that Gill's left arm (he is performing *hidari-ko-uchi-gari*, i.e., the left version of the throw, instead of *migi-ko-uchi-gari*, hence the switch in arms) is pushing only in front of *uke*'s right shoulder, instead of behind. In addition, Figure 7e shows that Gill does not maintain proper control with his *hara* 腹 [belly] which is insufficiently involved and is moving sideways to the left as is his reaping foot, instead of being pushed forward downward to the *tatami*.

here is meant to underpin the points raised in the above paragraphs, i.e., the complexities involved in correctly performing *ko-uchi-gari*. A theoretical comprehension of the different phases of a technique unfortunately does not yet guarantee proper performance. After all, the teacher or coach must be able to understand and discern these mistakes, and the *jūdōka* must master the motor skills necessary to do all these. This requires time, dedication, skills, and expertise for both the teacher and *jūdōka*. We believe that biomechanical analysis deserves a proper place in assisting in this process. Through understanding the biomechanics, one may better comprehend the effect of one's technical flaws and the impact of these on the desired outcomes. The Japanese have long understood and applied this. Yamaguchi's academic thesis explored the kinematics and biomechanics of *ko-uchi-gari* (Yamaguchi, 1992), and the same *jūdō* throw also has been the focus of an extensive study by Yabune, Tokuda, Nagatani, and Yano (2006), hence we refer to either these works or to Sacripanti's for those wishing to review the biomechanics of *ko-uchi-gari* in more depth. Furthermore, a few authors have also attempted kinematic or biomechanical studies on a number of other popular *jūdō* throws [Blais, 2004 (*seoi-nage* and *uchi-mata*); Himpe, 1978; Minamitani, Fukushima, & Yamamoto, 1988; Trilles, Lacouture, & Cadiere, 1990; Yabune, Tokuda, Nagatani, & Yano, 2005b (*uchi-mata*); Imamura, 1996; Imamura, Iteya, & Takeuchi, 2005; Imamura, Hreljac, Escamilla, & Edwards, 2006; Okada, 2008; Yabune, Tokuda, Nagatani, & Yano, 2005a (*ō-soto-gari*); Yabune, et al., 2006 (*ō-uchi-gari*); Imamura, et al., 2006; Imamura, Iteya, Hreljac, & Escamilla, 2007; Pucsok, Nelson, & Ng, 2001; Yabune, 1995 (*harai-goshi*); Harter & Bates, 1985 (*harai-goshi* and other hip throws); Imamura, et al.,



Fig. 8. Belgian former Olympic champion Robert Van de Walle (born 1954), 8th *dan*, is demonstrating *ko-uchi-gari* during a 2010 *jūdō* guest clinic. While it is reasonable to assume that Van de Walle is "being kind" to his much lighter *uke*, he does make the same mistake as Nicholas Gill did in Figure 7, failing to properly control with the *hara* 腹 [belly] and continuing to push the *hara* toward the ground into the moment of *zanshin* 残心 [the "follow through"]. Moreover, Van de Walle makes an additional mistake when compared to Gill, i.e., that his left arm has insufficient directional control (toward the *tatami* in order to keep *uke*'s ["the person being thrown"] balance on his heels). Gill in Figure 7 clearly has the better arm control. The fact that he is obviously able to "get his *uke* on the ground" is not relevant in this context.



Fig. 9. Okano Isao-sensei 岡野功 (born 1944) is seen here correcting Gill's error in *hara* 腹 [belly] control, mentioned in Figure 7, by showing how it needs to be done. The *hara* thus must be moved forward and pushed forward downward to the *tatami*. *Uke* is Okano-sensei's son Okano Tetsuo. Picture taken August 31, 2008.

2006; Yabune, Tokuda, Nagatani, & Yano, 2004; Yoshitaka, 1992 (*seoi-nage*]).

For those seeking guidance in the non-physical and non-biomechanical aspects of *ko-uchi-gari*, we refer to the books by Kudō (1967), Okano and Satō (1973), and Swain (1994), or the videos or DVDs by Okano (no date) or Mifune (Mifune, 1955). However, nothing replaces a qualified teacher who truly masters *kuzushi*, *debana*, and control, as did, for example, Okano Isao, Hirano Tokio, Marcel Clause (Clause, 2003), Mifune Kyūzō, and a handful of others.

Evaluation and conclusion of Sacripanti's biomechanics-based *jūdō* throws classification system

Sacripanti's work is the result of thorough insight into the physics and biomechanics of motion. As a physicist he was able to access, comprehend, and spearhead unexploited terrain in the application of physics to *jūdō*. In this paper we used the technique of *ko-uchi-gari* to partially evaluate the advantages and disadvantages of applying Sacripanti's approach. One can observe and apply the simple classification of his "Physical Levers" versus "Couple of Forces," perhaps with the sole caveat that the term "Simple Couple" probably is grammatically less confusing and mechanically less ambiguous. Whilst biomechanical analyses of *jūdō* throws have been in existence for nearly 60 years (Ikai & Matsumoto, 1958; Ikai, Asami, Kaneko, Sasa, & Matsumoto, 1963), Sacripanti went much further and provided a solid system that does not stop at analyzing standing *jūdō* throws, but also deals with *sutemi-waza*, *katame-waza*, *kumi-kata*, *ukemi*, balance, and even *jūdō* matches and scores.

Although Sacripanti's classification may not re-

place the *Kōdōkan* classification of throws, his system has considerable merit without that. We note that neither the Gleeson nor the Adams system has presented a real challenge to the *Kōdōkan* categorization, and *Kawai-shi's* system, which once was widely spread in Europe, in time was essentially overwhelmed by the *Kōdōkan* system. There may be merit to *jūdō* withstanding some "trendy" changes in technique classification, such as in particular terminology stemming from "Brazilian Jiu-Jitsu" (for example, "guard," "half guard," "the Kimura," and "the Ezekiel") since they do not facilitate better communication and achieving Kanō's educational goals. However, the *Kōdōkan* also suffers from the other extreme, i.e., a resistance against a modern restructuring of some of its teachings, even if a progressive approach might offer a valuable alternative from a pedagogical point of view.

Sacripanti's biomechanical classification is more extensive and comprehensive than the previous attempts in *jūdō* by other authors. For example, it is excellently suited for identifying mistakes, or for seeking application in identifying an opportune technical approach for athletes with injuries or those who have to face a particularly difficult opponent. *Kōdōkan jūdō* is a 19th-century pedagogy for which the philosophical principles may well coexist with the biomechanical expression even if a more scientific analysis can achieve selected objective results more effectively. In fact, we only see a minor temporary challenge in that *jūdō* teachers, instructors, and coaches will need to be trained in order to improve their understanding of the physics and biomechanics that are illuminated and emphasized by Sacripanti's approach.

References

- Adams, N. (1992) *Grips: judo masterclass techniques*. Bristol, UK: Ippon Books.
- Arima, S. (1906) *Jūdō: Japanese physical culture: being a further exposition of jujitsu and similar arts*. Tokyo: Mitsumura. Pp. 1-128.
- Bennett, A. (Ed. & Transl.) (2009) *Jigoro Kano and the Kodokan: an innovative response to modernization*. Tokyo: Kōdōkan jūdō Institute.
- Blais, L. (2004) Objective analysis of two judo throws: Seōi Nage and Uchi Mata: from mechanical reality to pedagogical applications. Unpublished doctoral dissertation, Univer. of Poitiers, France. [in French, with English abstract]
- Chen, J., & Chen, T. (2002) *Tokio Hirano (1922–1993) 8th Dan: the man who revolutionized judo*. Retrieved July 24, 2011, from <http://judoinfo.com/hirano.htm>.
- Clause, M. (2003) *Demonstration*. Videoclip retrieved July 24, 2011, from <http://www.youtube.com/watch?v=pEYLQKEEwN8>. [in French]
- Daigo, T. (2005) *Kodokan throwing techniques*. Tokyo: Kōdansha.
- De Créé, C. (2012) *Ryū-setsu: jūdō no musha shugyō* (柳雪、柔道の武者修行) [As snow on a willow: a pilgrimage in jūdō]. Cambridge, UK: Cambridge Univer. Press.
- De Créé, C., & Jones, L. C. (2009) Kōdōkan jūdō's elusive tenth kata: the Gō-no-kata. Forms of proper publication use of force. (Parts 1–3) *Archives of Budo*, 5(1), OF55-95.
- Fujiwara, T., Uchida, G. S., & Wilson, G. L. (1970) *Judo for high school: a handbook for instructors*. Kent, WA: United States Judo Federation.
- Geesink, A. J. (1967) *Gokyo: principles of judo*. London: W. Foulsham.
- Geesink, A. J. (2000) *Judo. Based on social aspects and biomechanical principles, divided in two parts*. Setagaya (世田谷), Tokyo, Japan: Kokushikan University (国士館大学).
- Giraldi, F. (1975) *Judo-kata:shintai kōki no kata*. Rome: Edizioni Mediterranee. [in Italian]
- Gleeson, G. R. (1984) *All about judo*. Wakefield, UK: EP Publishing.
- Harter, R. A., & Bates, B. T. (1985) Kinematic and temporal characteristics of selected judo hip throws. In J. Terads & J. N. Barham (Eds.), *Biomechanics in sport II: proceedings of ISBS, ors II*. Del Mar, CA: Research Center for Sports. Pp. 141-150.
- Himpe, S. (1978) Studie der fundamentele begrippen van het rechtstaand judo: biomechanische analyse van uchi-mata. Unpublished thesis M.P.E., Institute for Physical Education (I.L.O.), Catholic Univer. of Leuven (KU Leuven).
- Hirano, T. (平野時男) (1969) *jūdō sekai nage aru ki* (柔道世界投げ歩記) [Chronicle of walking around the world of jūdō throwing]. Self-published. Pp. 1-231. [in Japanese]
- Hofmann, W. (1977) "Hoho-Kata: Methodik-Kata." *Judo-Revue*, 2, 7-9. [in German]
- Ikai, M., Asami, T., Kaneko, M., Sasa, T., & Matsumoto Y. (1963) Electromyographic studies on the "Nage Waza" (throwing techniques) of Judo. In *Bulletin of the Association for the Scientific Studies on Judo: Report II*. Tokyo: Kōdōkan. Pp. 97-105.
- Ikai, M., & Matsumoto, Y. (1958) The kinetics of judo. In *Bulletin of the Association for the Scientific Studies on Judo: Report I*. Tokyo: Kōdōkan. Pp. 49-61.
- Imamura, R. T. (1996) A kinematic comparison of two styles of judo leg sweep in the major outer leg reap: osotogari. Unpublished master's thesis in physical education, School of Health and Social Work, California State Univer., Fresno, CA. Pp. 1-28.
- Imamura, R. T., Hreljac, A., Escamilla, R. F., & Edwards, W. B. (2006) A three-dimensional analysis of the center of mass for three different judo throwing techniques. *Journal of Sports Science and Medicine*, 5(CSSI), 122-131. Available from URL: <http://www.jssm.org>.
- Imamura, R. T., Iteya, M., Hreljac, A., & Escamilla, R. F. (2007) A kinematic comparison of the judo throw Harai-goshi during competitive and non-competitive conditions. *Journal of Sports Science and Medicine*, 6(CSSI-2), 15-22.
- Imamura, R. T., Iteya, M., & Takeuchi, Y. (2005) *The biomechanics of Osoto-gari*. In *Bulletin of the Association for the Scientific Studies on Judo: Report X*. Tokyo: Kōdōkan.
- Kane, T., & Levinson, D. A. (1985) *Dynamics: theory and applications*. McGraw-Hill series in mechanical engineering. New York: McGraw-Hill. Pp. 94-99.
- Kanō, J. (嘉納治五郎) (1930a) Kata randori renshū no mokuteki (w)ō ronzu (Sono ichi) [道場に於ける: 形乱取縋習の目的を論ず (其の一)] [The meaning of kata and randori practice: Part 1]. *jūdō*, 1(2), 2-3. [in Japanese]
- Kanō, J. (嘉納治五郎) (1930b) Kata randori renshū no mokuteki (w)ō ronzu (Sono ni) [道場に於ける: 形乱取縋習の目的を論ず (其の二)] [The meaning of kata and randori practice: Part 2]. *jūdō*, 1(3), 2-4. [in Japanese]
- Kanō, J. (嘉納治五郎) (1930c) Kata randori renshū no mokuteki (w)ō ronzu (Sono san) [道場に於ける: 形乱取縋習の目的を論ず (其の三)] [The meaning of kata and randori practice: Part 3] *jūdō*, 1, 2-5. [in Japanese]
- Kanō, J. (嘉納治五郎) (1931) *jūdō kyōhon jōkan* (柔道教範 上潘) [A textbook of jūdō]. Tokyo: Shushiki Kaisha. Pp. 1-127. [in Japanese]
- Kanō, J. (2006) *Mind over muscle: writings from the founder of judo*. (N. Murata, Ed., & N. H. Ross, Transl.) Tokyo: Kōdansha.
- Kanō, Y. (嘉納行光), Kawamura, T. (川村禎三), Nakamura, R. (中村良三), Daigo, T. (醍醐敏郎), Takeuchi, Y. (竹内善徳), & Satō, N. (佐藤宣践) (Eds.) (1999) *jūdō daijiten* (柔道大事典). Tokyo: Athene Shobō. P. 117. [in Japanese]
- Kanō-sensei Denki Hensankai (嘉納先生伝記編纂会) [Editorial Committee for the Biography of Kanō-sensei]. (Eds.) (1984) *Kanō Jigorō* (嘉納治五郎) Tokyo: Kōdōkan. Pp. 351-373. [in Japanese]
- Kawaishi, M. (1951) *Ma méthode de judo*. Paris: Imp. Cario; p. 36. [in French]
- Kōdōkan (Eds.) (1986) *Illustrated Kodokan judo*. Tokyo: Kōdansha.
- Koizumi, G. (1960) *My study of judo*. New York: Sterling.
- Kudō, K. (工藤一三) (1967) *Dynamic judo: throwing techniques*. Tokyo: Japan Publications.
- Magara, H. (真柄 浩) (1992) Kōdōkan jūdō no waza jutsu meijō (諸道館柔道の技術名称) [Nomenclature of Kōdōkan jūdō techniques]. *Meiji Daigaku Kyōyō Ronshū* (明治大学教養論集) [Meiji University Collection of Educational Essays Physical Education], *Taiiku Gaku* (体育学) [Physical Education], 250, 1-17. [in Japanese]
- Maruyama, S. (丸山三造) (1939) *Dai Nihon jūdō shi* (大日本柔道史) [Complete history of Japanese judo]. Tokyo: Kōdōkan (講道館). Pp. 999-1040. [in Japanese]
- Mifune, K. (三船久蔵) (1955) *Shingi Mifune Judan [kanzenhan]: jūdō no shinzui* (神技 三船十段 『完全版』 柔道の真髓) [Mifune 10th dan [complete edition]: The essence of jūdō]. [DVD] *Nihon Eiga Shinsha* (日本映画新社), 1955. Tokyo: Quest Co., Ltd., DVD SPD-3514. [in Japanese]
- Mifune, K. (三船久蔵), Kudō, K. (工藤一三), & Matsumoto, Y. (松本芳三) (Eds.) (1955–56) *jūdō kōza* (柔道講座) [Course of jūdō]. Vol. 1–5. Tokyo: Shiromizu-sha (白水社). [in Japanese]

- Minamitani, N., Fukushima, M., & Yamamoto, H. (1988) Biomechanical properties of judo throwing technique, uchimata, especially for newly developed flamingo technique. In E. Kreighbaum & A. McNeill (Eds.), *Biomechanics in Sports VI: Proceedings of the 6th International Symposium on Biomechanics in Sports*, Bozeman, MT: Department of Health and Human Development, Montana State Univer. Pp. 245-251.
- Monti, A., & Sacripanti, A. (1995) *Judo: prospetto sintetico*. Self-published. [in Italian]
- Oimatsu, S. (老松信一) (1976) *Kaitei shinpan jūdō hyakunen* (改訂新版柔道百年) [Revised edition of *One hundred years of jūdō*]. K. Satō (Ed.). Tokyo: Tokimune Tsūshinsha (時事通信社), Pp. 40-53. [in Japanese]
- Okada, H. (岡田弘隆) (2008) Jissai no shiai ni okeru ju no kuzure ni kansuru kenkyū: Kanō Jigorō hata Kokusai Taikai ni okeru ō-soto-gari (w) o taishō ni. (実際の試合における受の崩れに関する研究 — 嘉納治五郎杯国際柔道大会における 大外刈を対象に —) [Study of breaking the opponent's balance in ō-soto-gari during the Jigorō Kanō Cup 2005]. *Tsukuba Daigaku Taiku Kagaku Kei Kiyō* (筑波大学体育科学系紀要) [Bulletin of the Institute of Health & Sports Science, University of Tsukuba], 31, 171-174. [in Japanese]
- Okano, I. (岡野功) (no date) Okano Isao no vaitaru jūdō: Watakushi no tokui-waza – Dai ichi-kan & Dai ni-kan (岡野功のヴァイタル柔道。私の得意技 – 第1巻 & 第2巻) [Okano Isao's vital judo: my preferred techniques. Vols. 1 & 2]. [VHS Videotapes] Self-published. [in Japanese]
- Okano, I., & Satō, T. (1973) *Vital judo: throwing techniques*. Tokyo: Japan Publications.
- Pucsok, J. M., Nelson, K., & Ng, E. D. (2001) A kinetic and kinematic analysis of the harai-goshi judo technique. *Acta Physiologica Hungarica*, 88 (3-4), 271-280.
- Sacripanti, A. (1987) Biomechanical classification of judo throwing techniques (Nage Waza). In L. Tsarouchas, J. Terauds, B. A. Gowitzke, & L. E. Holt (Eds.), *Proceedings of the 5th International Symposium of Biomechanics in Sport (ISBS)*. Athens: Hellenic Sports Research Institute. Pp. 181-194.
- Sacripanti, A. (1997) *Contest dynamics: general biomechanical theory of contest sports*. arXiv:0806.4069v1. P. 10.
- Sacripanti, A. (2010) ENEA (Ente per le Nuove tecnologie l'Energia e l'Ambiente [Italian National Agency for New Technologies, Energy and Sustainable Economic Development]) technical report RT/INN/97/25. Rome: ENEA. In *Advances in judo biomechanics research: modern evolution on ancient roots*. Saarbrücken, Germany: VDM Verlag, Dr. Müller Aktiengesellschaft.
- Sacripanti, A. (2011) *Judo biomechanics*. Unpublished syllabus for master's degree in teaching and coaching judo & European judo union master coach (Level 6), Department of Medicine and Surgery, University of Rome "Tor Vergata," Italy. Pp. 1-560.
- Sasaki, K. (1907) *Djudo a Japán dzsiu-dzsiu tökéletesített módszer* [Jūdō: improved method of Japanese jūjutsu]. Budapest, Hungary: Hornyánszky Viktor. Pp. 83-85. [in Hungarian]
- Steidele, G. (1999) *Rensa no kata* (連鎖の形) [Forms of chain-techniques]. Brunnthal, Germany: Gerhard Steidele Videoproduktion. [in German]
- Swain, M. (1994) *Ashiwaza II: ouchi-gari, kouchi-gari, kosoto-gari*. London: Ippon Books.
- Trilles, F., Lacouture, P., & Cadere, R. (1990) Analysis of several modes using the same throwing technique (Uchi Mata) didactical purpose from a mechanical study (Abstract). *Science et Motricité*, 10, 33-43. [in French]
- Uchida, R. (内田良平) (1903) *jūdō* (柔道). Tokyo: Kokuryūkaï Shuppan (黒龍會出版) [Black Dragon Society Publishers]. Pp. 1-190. [in Japanese]
- Watanabe, I. (渡邊一郎) (Ed.) (1971) *Shiryō: meiji budō shi* (史料明治武道史) [Archives of the history of martial arts during the Meiji Period]. Tokyo: Shinjinbutsu Ōrai-sha (新人物往來社). Pp. 79-97. [in Japanese]
- Yabune, T. (藪根敏和) (1995) Dōsa to ryō-ude, ryō-kyaku no hakki ryoku kara mita harai-goshi no kenkyū (動作と両腕・両脚の発揮力からみた払腰の研究) [A study of harai-goshi from the viewpoint of the motion and forces exerted by arms and legs]. *Kyōto Kyōiku Daigaku Kiyō* (京都教育大学紀要) [Bulletin of Kyōto University of Education Series B], 86, 17-34. [in Japanese]
- Yabune, T. (藪根敏和), Tokuda, S. (徳田真三), Nagatani, Y. (長谷川裕), & Yano, M. (矢野勝) (2004) *jūdō nage-waza no honegumi seoi-nage* [The framework of jūdō throwing techniques: seoi-nage] (柔道投技の骨組み 背負投). Tokyo: Fumaidō Shuppan (不昧堂出版). Pp. 1-92. [in Japanese]
- Yabune, T. (藪根敏和), Tokuda, S. (徳田真三), Nagatani, Y. (長谷川裕), & Yano, M. (矢野勝) (2005a) *jūdō nage-waza no honegumi ō-soto-gari* [The framework of jūdō throwing techniques: ō-soto-gari] (柔道投技の骨組み 大外刈). Tokyo: Fumaidō Shuppan (不昧堂出版). Pp. 1-95. [in Japanese]
- Yabune, T. (藪根敏和), Tokuda, S. (徳田真三), Nagatani, Y. (長谷川裕), & Yano, M. (矢野勝) (2005b) *jūdō nage-waza no honegumi uchi-mata* [The framework of jūdō throwing techniques: uchi-mata] (柔道投技の骨組み 内股). Tokyo: Fumaidō shuppan (不昧堂出版). Pp. 1-104. [in Japanese]
- Yabune, T. (藪根敏和), Tokuda, S. (徳田真三), Nagatani, Y. (長谷川裕), & Yano, M. (矢野勝) (2006) *jūdō nage-waza no honegumi ō-uchi-gari – ko-uchi-gari* [The framework of jūdō throwing techniques: ō-uchi-gari & ko-uchi-gari] (柔道投技の骨組み 大内刈・小内刈). Tokyo: Fumaidō shuppan (不昧堂出版); Pp. 1-97. [in Japanese]
- Yamaguchi, K. (1992) The kinematical study of judo throwing technique "ko-uchi-gari." Unpublished thesis, M.P.E., Institute of Health and Sports Sciences, Tsukuba Univer., Tsukuba, Ibaraki, Japan. [in Japanese, with English abstract]
- Yiannakis, L. (2011) A taxonomy of principles used in judo throwing techniques. *Journal of Asian Martial Arts*, 20(3), 92-107.
- Yokoyama, S. (横山作次郎), & Ōshima, E. (大島英助) (1908) *jūdō kyōhan* (柔道教範) [Learning text of jūdō]. Tokyo: Nimatsudō Shoten (二松堂書店). [in Japanese]
- Yokoyama, S., & Ōshima, E. (1911) *jūdō. Manuel de jiu-jitsu de l'école de Kano à Tokio*. (Y. Le Prieur, Transl.) Paris & Nancy, France: Berger-Levrault Éditeurs. [in French]
- Yoshitaka, Y. (1992) A biomechanical study on the seoi-nage techniques. Unpublished thesis, M.P.E., Institute of Health and Sports Sciences, Tsukuba University, Tsukuba, Ibaraki, Japan. [in Japanese, with English abstract]

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