

O Soto Gari vs. Pardelera. A descriptive kinematics study of a laboratory sample

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1998

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Abstract

A three dimensional analysis was used to compare the technical execution of two techniques of two very similar types of struggle. One, from a Japanese Martial Art known as Judo, and the other from The Canary Islands, called Canarian Wrestling. We explored these techniques with the possibility of bring something new to a young sport from another older sport. Judo was founded by Jigoro Kano at the end of 19th century, while Canarian Wrestling existed before the Spanish conquest of the Canary Islands (second half of 15th century) and so was practiced by aborigines.

We have studied important parameters such as linear velocity, angular velocity and joint angles, of two opponents in two specific techniques: O Soto Gari (OG) of judo, and Pardelera (P) of Canarian Wrestling. We have obtained that both techniques can be used independently of what kind of sport modality we play. However, P is a leg-based technique executed through the arms, while OG uses mainly the lower limb, so for each technique the wrestler must train different muscles. Finally, OG and P are basically identical, although the different starting position and grasping styles condition the progress of combats. So, P can be used in a Judo combat and vice versa, and OG can be used in a Canarian Wrestling combat.

Key words: Canarian Wrestling, judo, biomechanics, three dimensional analysis, Celtic wrestling.

Introduction

Kinematics has been used for comparing two technical executions: O Soto Gari (OG) from judo, and Pardelera (P) from Canarian wrestling. Such a comparison has allowed assessment of similarities between both sportive modalities, which differ not only in their geographic location but also in their time of existence. It is known that judo originated in Tokyo (Japan) and was founded by Professor Jigoro Kano at the end of XIX century [6, 8]; while Canarian wrestling appeared well before the Spanish conquest of the Canary Islands (second half of 15th century) and so was practiced by aborigines, no founder having been recognized. The first written testimony can be encountered in a XV century chronicle by Alvar García de Santa María, Royal Chronicler of Juan II's Court, Kingdom of Castilla [10].

The comparison is also important due to the great adaptability showed by Canarian wrestlers. Proof of that is the fact that Canarian wrestling was considered a source of championship into other related disciplines (judo, sampo, grecoroman and Olympic wrestling) while linked to the Spanish Federation of Wrestling. Actually the Canarian Wrestling Federation exists as a separate organization.

From a technical point of view, the loser of a Canarian combat is the wrestler compelled to touch the ground with any part of the body other than the soles [17]. Wrestling uniforms consist of a short-sleeved shirt and trousers down to the knees (*calzón*) and rolled up at the middle of the thigh, both being made of strong fabrics. Techniques involve every corporal segment but, unlike judo, strangulation and dislocation are not allowed and there is no ground fighting. Intended strikes are illegal as well. Before a fight starts, both contenders must greet each other while shaking hands, and subsequently join their respective right shoulders and bend themselves forward. Next, the left hand grasps the opponent's trousers by the right opening edge, whereas both right hands are placed palm to palm and lowered to the ground. Then, the referee lets the match begin and the wrestlers separate their right hands and attack immediately. In a confrontation between two teams (twelve wrestlers per team), which is the most common practice, there is no weigh criteria. As a wrestler is generally out when thrown

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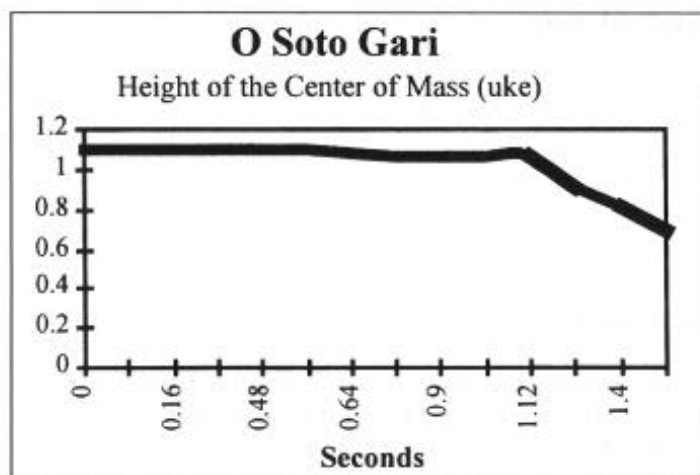


Figure 1. Height of the Uke's Center of Mass in O Soto Gari.

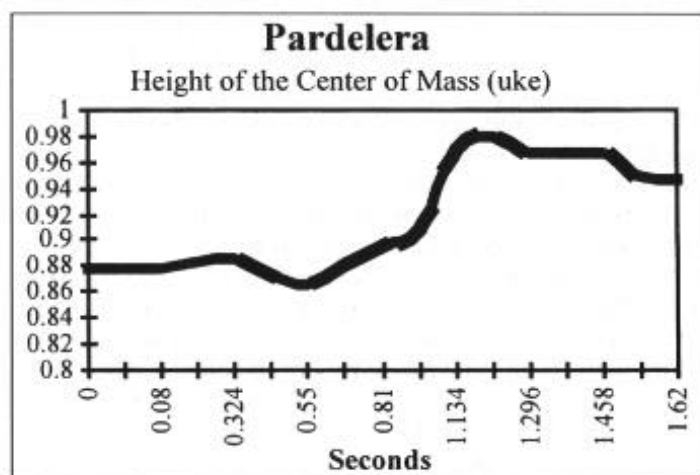


Figure 2. Height of the Uke's Center of Mass in Pardelera.

twice, team strategies, similar to chess tactics, are designed by the mandador (team leader) who is an experienced strategists. Fights last between 1.5 and 2 minutes.

The absence of weight categories often results in wrestlers combating opponents exceeding their weight by 20-30 kg. There is however a classification of wrestlers by merit. All wrestlers within a team are scored by the Canarian Wrestling Federation, producing a total team scoring which must be within a given interval. This interval varies according to the category of competition; i.e. teams' scoring in the top category ranges between 5 and 7 points, bearing in mind that the best wrestlers are worth 3 points (*puntal A*), the score being 2 (*puntal B*), 1 (*puntal C*) and 0 (unclassified) for gradually less valuable wrestlers.

In judo, a further extended and known discipline, the

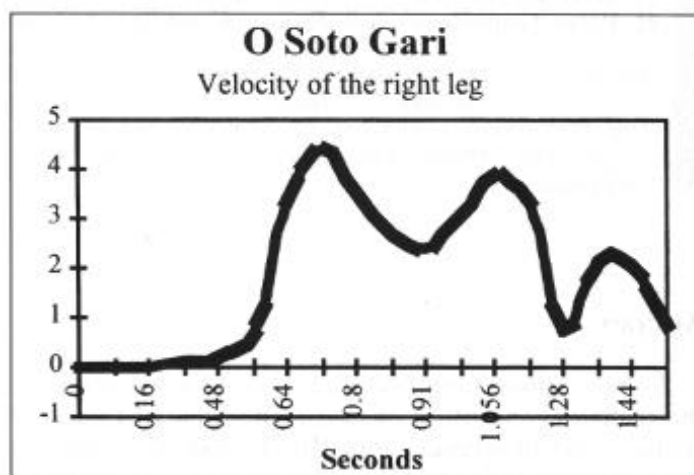


Figure 3. Velocity of the right leg in O Soto Gari.

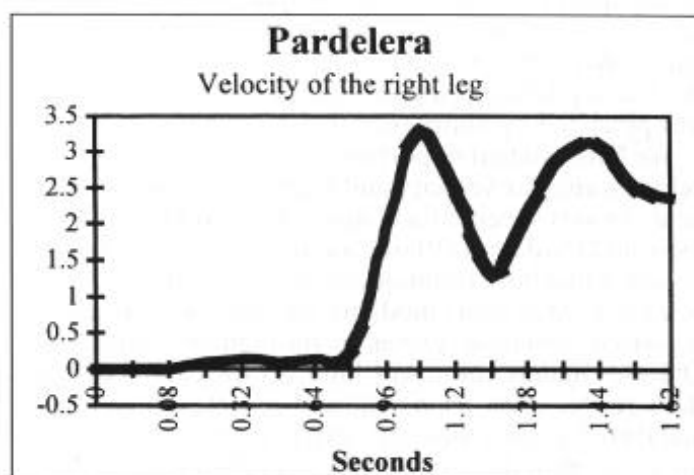


Figure 4. Velocity of the right leg in Pardelera.

aim is always to bring the opponent down by means of a perfectly executed technique or perfect point (*ippon*), which is considered the most spectacular judo technique by Trilles et al. [19]. Other important techniques include immobilization of the opponent having the back on the mat for 30 seconds, and surrender under threat of strangulation (*shime waza*) or joint dislocation (*kansetsu waza*) [7, 12]. Judo uniforms or judogi consist of a jacket, long trousers, and a belt, all of durable materials [7]. Combatants start off after a formal bow in the most orthodox Eastern tradition. Unlike Canarian wrestling, there is no position of initial grasp, but contenders must struggle to achieve it (*kumikata*) in a sort of preliminary combat which will be of prime importance to the final output [19]. The so-called traditional grasp consists of holding the opponent's costume by the left lapel and the right elbow, though there is a whole array of grasping

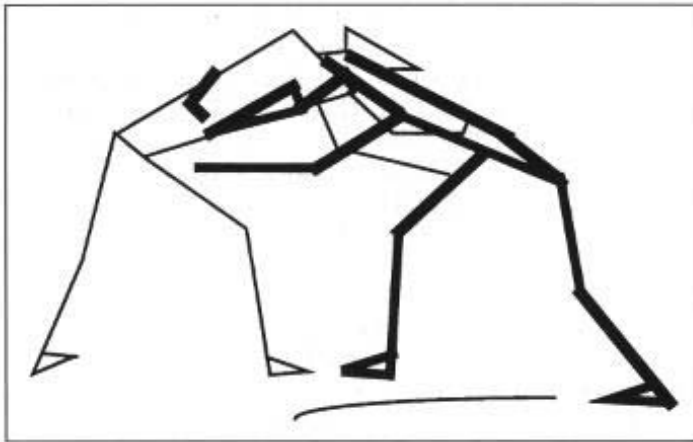


Figure 5. The Canarian Wrestler position just before phase 1. The line on the floor indicates the trajectory of the Tori's left leg.

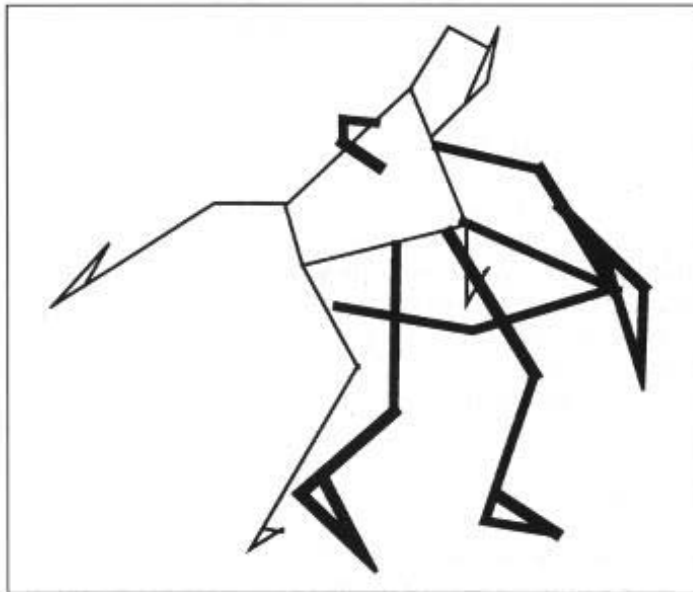


Figure 6. Extension and lateralisation to the right.

styles. In judo, confrontations usually take place on an individual basis, although there exist team competitions with a clear classification of combatants according to their weight.

To sum up, both judo and Canarian wrestling are arts in which a slim person can throw a greater and stronger opponent provided that strength is efficiently employed [16].

Material and methods

This study was undertaken by means of two fixed SVHS video cameras (mod. TK-1280 E), whose optical

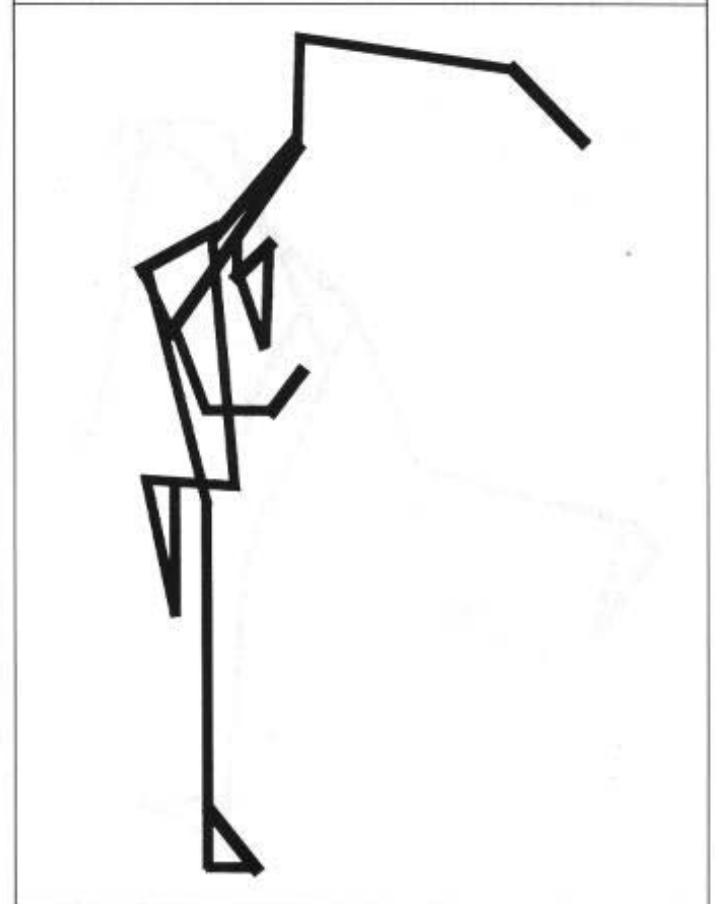


Figure 7a and b. Two points of view of the end of Pardelera.

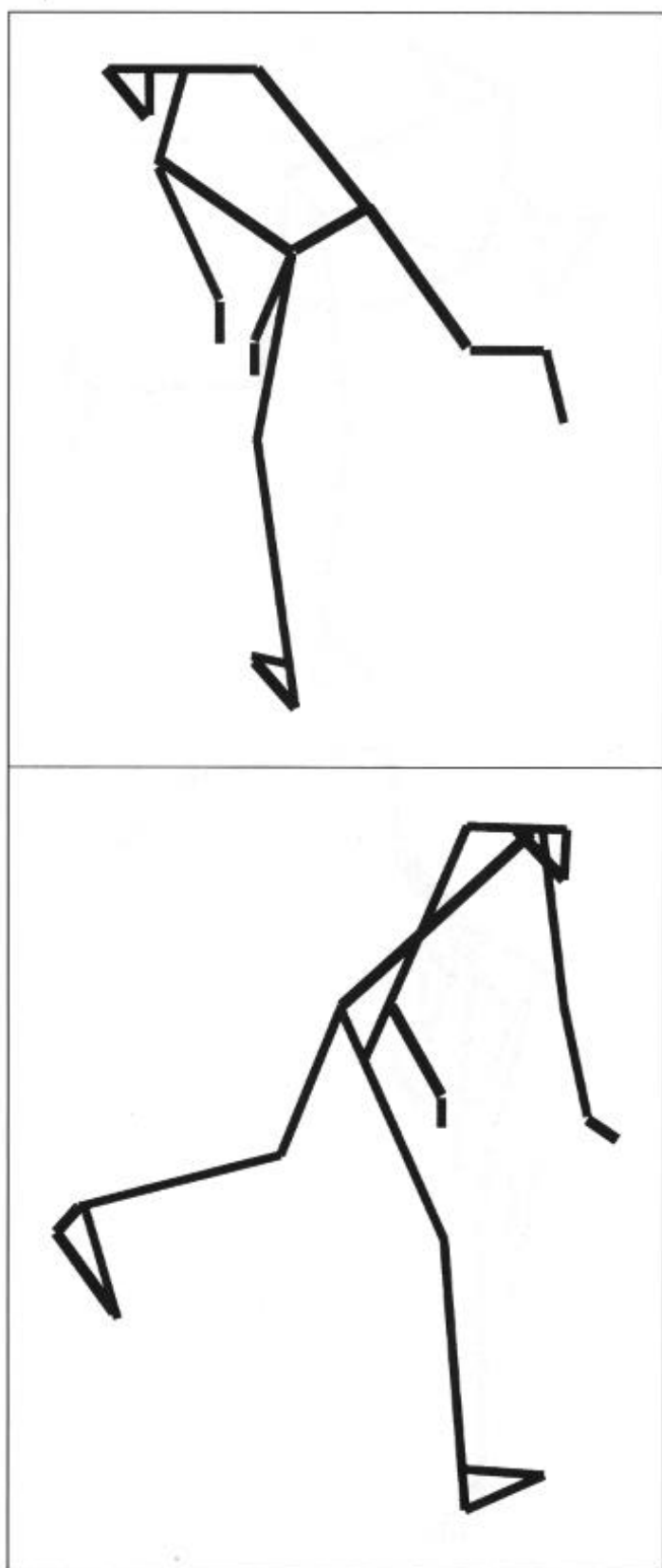


Figure 8a and b. Two points of view of the end of O Soto Gari.

axes were positioned obliquely to the execution of movement and forming an angle of 90° between each other. Cameras were genlocked and time code synchronised with the use of two ALPERMANN-VELTE-TC30 time code generators. The time code was inserted in the video image with the use of two ALPERMANN-VELTE-TC30 readers-inserters to facilitate the posterior analysis. Space was calibrated through a control object of known coordinates (24 points) and a volume of $3 \times 4 \times 3$ m. Three-dimensional assessment (3D) was carried out with the Direct Linear Transformation technique for 11 parameters (DLT-11) on the package PEAK PERFORMANCE Version 5 (Peak Performance Inc., Englewood, Colorado), whereby the coordinates of 22 landmarks of the wrestler's body could be determined. The average error in the estimation of 3D points was 0.005 m. Data were collected at 50 Hz, and the 22 body landmarks were manually digitized in each frame for both cameras. The resolution of the digitizer was 1024H x 960V. Wrestlers had at least 10 years experience in their respective disciplines. Judoka and Canarian wrestler had heights of 170 cm and 178 cm, and weighed 70 and 85 kg, respectively. Five trials were performed per each subject.

The two wrestling techniques were split into 3 phases as follows:

Phase 1 (Ph1): Tori (T) or executor pulls Uke (U) or opponent with the right arm while the left foot is lifted and moved forward and sideways.

Phase 2 (Ph2): Tori raises the right foot and thrusts Uke backwards with the right arm.

Phase 3 (Ph3): Tori's right leg sweeps Uke's right leg triggering the throw.

Results

1 - Temporal Length of phases

Regarding the length of the two technical executions, Perdelera (1.54 s) was longer than O Soto Gari (1.28 s). However, phases had a similar length in OG (Ph1: 0.44; Ph2: 0.34; Ph3: 0.5 s), while P spent most of the time in Ph2 (1.36 s). Perdelera phases 1 and 3 lasted less than any OG phase.

2 - Tori's and Uke's CM

Tori's CM descended from Ph1 to Ph3 in OG, as opposed to that of Perdelera which underwent a slight ascension from Ph1 to Ph2 before descending altogether below Ph1.

Tori's CM had a *horizontal resultant* (displacement through the horizontal plane) (Figure 9) that was larger for OG (93.1 cm) than for P (74.52 cm).

The *velocity* of this displacement depended on the technique and phase considered. Thus, in the Japanese

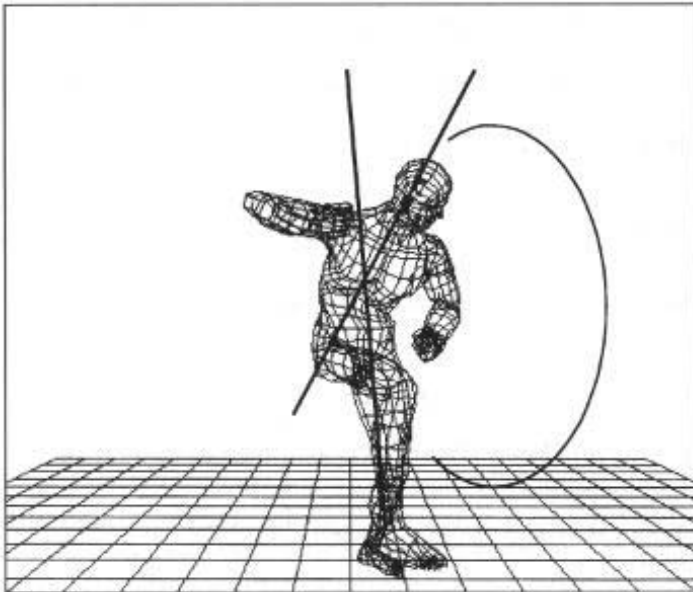


Figure 9. Trunk-resting leg angle (frontal view, Tori in Canarian Wrestling).

technique, the CM moved at a fairly constant speed between the first two phases (153 cm/s and 156 cm/s, respectively), and decreased in Ph3 (60 cm/s). However, Tori's CM velocity in P increased from Ph1 to Ph2 (42.2 cm/s to 112.6 cm/s, respectively) and decreased in the final phase (53 cm/s). Moreover, it must be pointed out that Tori's CM velocities in any one phase were always higher in OG than in P.

Relative to the ground, Uke's CM progressed in a fashion similar to that of Tori's CM in each technique. So, it descended from Ph1 to Ph3 in the judo discipline; while in P it ascended up to 9 cm between Ph1 and Ph2 and had a final descent in the last phase. Considering differences in height between the start of the technique and that of the throw (first part of Ph3), the CM experienced a lift in OG, whereas it went down in P, the variation being 3.3 cm and 8.7 cm, respectively.

The distance between Tori's CM and Uke's CM at the moment of major contact was smaller in OG (36 cm) than in P (38.6 cm).

3 - Angles

The *angulation* of the trunk relative to the resting limb (the left leg in both disciplines) (Figure 10), was always between 139° and 96° for OG. In P, maximum and minimum angulations were 126° and 57°, respectively. Therefore, the Japanese technique allows truncal movements of some 43°, while they are up to 69° in Canarian wrestling.

The maximum angular velocity of the trunk was reached in Ph2 in OG (115°/s), and in Ph3 in P (33°/s).

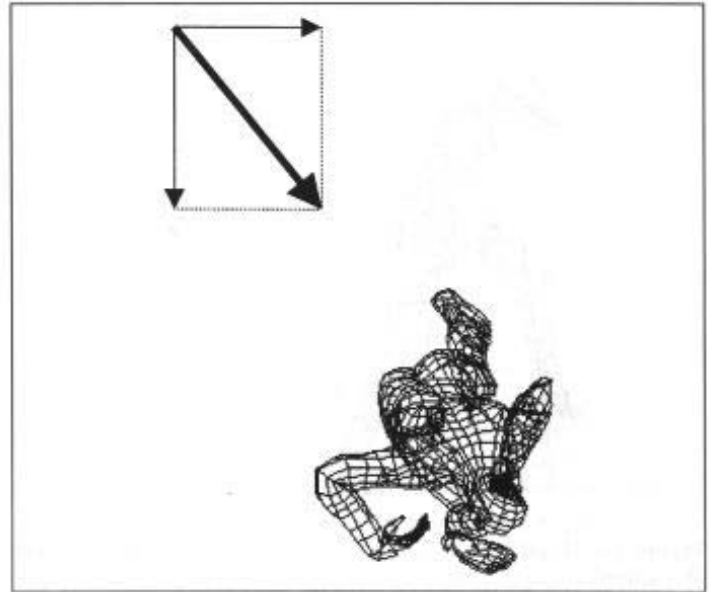


Figure 10. Horizontal center of mass displacement (top view, Tori in Canarian Wrestling).

Minimum trunk velocities occurred in Ph3 in OG (2°/s), and in Ph2 in P (12°/s).

The flexion of the sweeping knee (Figure 11) was greater in OG (O Soto Gari literally means "the great exterior sweep") (79°) than in P (84°), and a similar pattern occurred for the extension of this knee which amounted to 157° and 140° for OG and P, respectively.

Maximum and minimum angular velocities of the knee joint occurred in Ph3 (631°/s) and Ph2 (54°/s) in OG, respectively. While in P they occur in Ph2 (237°/s) and Ph1 (58°/s), respectively.

The distance between inferior limbs (Figure 12) was

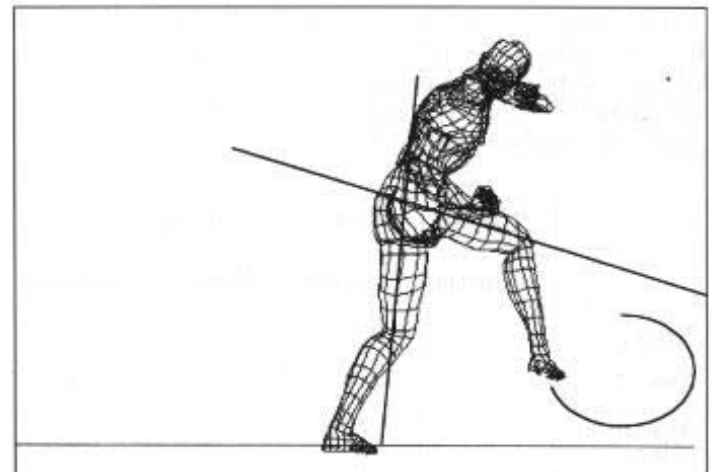


Figure 11. Angle between legs (right side view, Tori in Canarian Wrestling).

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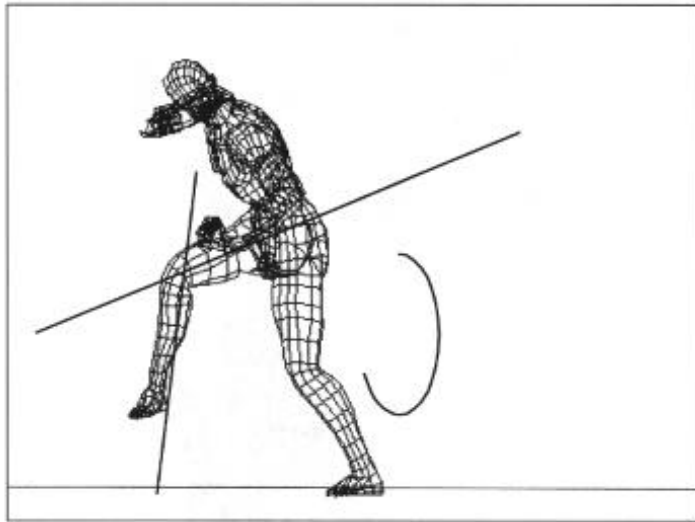


Figure 12. Right knee angle (left side view, Tori in Canarian Wrestling).

also larger in OG than in P, ranging between 75° and 4° (OG) and between 59° and 16° (P).

Maximum angular velocity of the sweeping leg was $434^\circ/\text{s}$ in Ph2 for OG, and $182^\circ/\text{s}$ in Ph3 for P, while minimum velocities for that leg occurred in Ph1 for both OG ($153^\circ/\text{s}$) and P ($8^\circ/\text{s}$).

Angulation data described above can be summarised as shown in Table 1. Velocities of ankle and wrist joints were also calculated and are shown in Figure 3 and 4, and Table 2. Table 3 shows the height of tori's CM and the distance between T's and U's CM at the time of most contact moment.

Discussion

The comparison between the two techniques described in this paper is complex, particularly due to the many changes in posture and opposition during a single combat. However, several conclusions can be drawn and employed to improve both O Soto Gari and Perdelera.

	O SOTO GARI		PARDELERA	
	Maximum	Minimum	Maximum	Minimum
Trunk	139	96	126	57
Knee	157	79	140	84
Abduction of legs	75	4	59	16

Table 1. Trunk and right knee angles and abduction of legs (degrees).

	O SOTO GARI			PARDELERA		
	Phase 1	Phase 2	Phase 3	Phase 1	Phase 2	Phase 3
Right ankle	1.007	4.393	3.882	0.055	3.277	3.047
Right wrist	1.063	1.893	3.304	0.665	2.171	2.449

Table 2. Rights ankle and wrist velocities (meters/seconds).

	O SOTO GARI			PARDELERA		
	Phase 1	Phase 2	Phase 3	Phase 1	Phase 2	Phase 3
Height of Tori's CM (cm)	81.2	75.6	66.4	90	91.1	87.7
Distance between T's & U's CM at the time of most contact moment (cm)	36			38.6		

Table 3. Height of Tori's CM and distance between T's and U's CM at the time of most contact moment (cm).

The split of both techniques into 3 phases according to certain events enhanced sound comparisons between them and constituted a new device through which the two techniques can assist each other when the situation and position of the wrestlers was appropriate, i.e. a judoka adopting at some point of the combat a position similar to that of a Canarian wrestler may execute a "modified OG"; or vice versa, a Canarian wrestler may execute a "modified P" when convenient.

Nevertheless, phase lengths vary considerably between techniques. Thus, the Canarian wrestler employs 88% of the P execution time for unbalancing Uke. This is achieved by the right arm thrusting the opponent backward (Ph2). The remaining two phases (Ph1 and Ph3) together use less time than any OG phase individually. In contrast, the distribution of time among phases is homogeneous in judo, the Japanese technique overall being quicker than P. It should be noticed that the Canarian wrestler has to displace Uke's body from a forward bent position (126° if Tori and Uke are equally bent from the beginning) to its extension and lateralisation to the right (Figure 6), while the judoka starts

with a larger extension of the trunk. It can then be inferred that in order to speed up a *Pardelera* the compromise may well be to reduce the length of phase 2, though in doing so the efficiency of the technique could be jeopardized (see below). However, in OG if the length of the right hand thrust was increased, Uke would be brought down before the end of the technique, and this would not correspond with a OG.

When the height of the Center of Mass is assessed, it can be seen that the judoka's CM always moves downward following through with the gravitational force. In contrast, the Canarian wrestler moves the arm initially upward (action ending in Ph 2) and subsequently downward (Ph 3). This is accounted for by the starting position of the two techniques [7, 17]. The elevation of CM in P entails an additional energetic expenditure which is nonetheless outweighed by an efficient utilization of strength. Indeed, Uke straightens in reaction to Tori's phase 1, so Tori follows through with that movement by a further small force that easily shifts Uke's CM. Thereafter, and from a larger height, Tori invests the gained potential energy in the throw of the opponent [25, 26]. The judoka also causes a reaction force from Uke through phase 1, reflecting an appropriate investment of strength [9, 16, 23]. However, since the starting position of the body is further extended in judo, Uke's reaction force is probably smaller (than in P) on the basis of the law of muscular contraction efficiency: a muscle develops the uppermost active tension if stretched beyond its normal resting length [4, 14]. In our case, the spinal triceps, has an important share in the maintenance of dynamic equilibrium [3, 21, 22]. Given the judoka's position (138° extended), the spinal triceps will be less stretched than that of a Canarian wrestler, whose spinal triceps will require larger tension to be made to stretch. At a lumbar level, the magnitude of the Moment of Force also increases with increasing trunk flexion, as asserted by Zatsiorsky [26] and Proubasta et al. [11]. Furthermore, Uke's impact on the ground is larger in OG than in P, since in the former Uke experiences a gradual fall from a larger height, while in the latter the movement undergoes an initial ascension (Uke's straightening) followed by a descent to the completion of the throw.

Concerning the attacker's right knee angulation, the extension of the joint is larger in OG than in P, implying larger quadriceps contraction in OG than in P [13, 18, 24]. Likewise, the knee flexion is larger in OG for which there is a larger tension over the muscular groups of the leg and thigh posterior regions (small and long biceps femoris, semimembranosus, semitendinosus, gastrocnemius, sartorius, and popliteus muscles) [13, 18, 24] than in P. Technically speaking, in P the right leg is only used to overcome the small opposition from Tori's right leg in a position of unstable balance (the CM is on

the edge of the supporting surface or out of it), as the main unbalancing action is caused by the arms. In fact, it can be asserted that "P is a leg-based technique executed through the arms". The judoka, however, intends to strongly sweep Uke's resting leg, the aim being taking advantage of the pendulum effect experienced by the attacking leg (this leg uses the gravitational force while descending according to the description of the simple pendulum [4, 25]); this is therefore a "technique of high cost-effectiveness" as suggested by Ueya [20] and Brousse [1]. To achieve this, the judoka's knee must be extended even more than that of the Canarian wrestler. Furthermore, the sign of the acceleration at which the right leg impacts the opponent's homologous leg depends on the technique employed. Thus, as described in the results section, when the judoka reaches that moment the acceleration decreases (deceleration), while the Canarian wrestler increases the attacking leg velocity on impact. Therefore, the action of the arms dominates P, whereas the right leg is the main acting member in OG. It can be derived from the latter that in developing an efficient P, the Canarian wrestler must focus on strengthening the musculature of the trunk and that of the scapular waist, including upper limbs, development of legs being of secondary importance. In contrast, the judoka must strengthen the musculature of the lower limbs for improving OG, and should further strengthen the upper region of the body for the execution of the "modified OG" as described in this paper.

Muscles acting upon the approach and separation of the hip joint are also larger in OG than in P as a result of the major and minor angulation between the lower limbs in the Japanese technique. So the tensor muscles of the fascia lata and medium and minor glutea exercise abduction, and the major, medium and minor abductors and, partly, the pectineous muscle operate upon the approach of the hip joint [15, 18, 24].

Velocities of the right leg (relative to the right ankle) and the right arm (relative to the right wrist) present similar trends in the two techniques studied, despite being of different magnitudes. Indeed, the right leg maximum velocity always occurs in phase 2 while right arm maximum velocities do so in phase 3.

This work shows that Tori's horizontal resultant entails smaller horizontal displacement in P (74.52 cm) than in OG (93.1 cm), which can be explained by the fact that starting positions are different in both techniques, such that the minimum distance between Tori's CM and Uke's CM is larger in P. This may contrast with the fact that contact between Canarian Wrestlers is larger than between judokas; however, the Canarian grasp of the calzón and the back gives further control between combatants than the judo grasp by the lapel and the sleeve (grasp - *kumikata* - traditional). In Canarian

wrestling, control centers upon the trunk and lower limbs, even though this is only for the "perception of action" so called by Trilles et al. [19], while in judo only the trunk is particularly controlled. Similarly, Mirallas-Sariola [8] suggested that if contact was suppressed, the exploitation of the forces generated by the body and the kinetics of the movements would be limited.

The fact noted by Sacripanti [12] that the fundamental principle of all kind of fights is the same and disciplines only differ in their rules allowing or banning certain actions, can also encompass Canarian wrestling and Judo. Thus, the use of OG does not break the rules of the Canarian wrestling [17], and vice versa, P can be legally used in judo [2, 5].

Conclusions

In summary, it can be asserted that both OG and P are basically identical, though the different starting positions and grasping styles condition the progress of combats. Both the judoka and the Canarian wrestler can potentially benefit from each other's techniques. Is the surprise factor not invaluable during a combat? Executing a Pardelera in a judo combat may well be decisive between combatants who know each other well, and this is no doubt a passport for success.

Acknowledgements

This study was supported by a Grant for Stay in Other Centers through The Department of Education, Culture and Sport of the Canary Islands' Government.

The authors would also like to acknowledge Carles Turro, Jordi Carles and Josep Escoda for their assistance with the video and computer analysis, and to Jaume Miralles for his supervision of Judo technique.

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