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6 **TITLE PAGE**  
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9 **TITLE: Beneficial effects of karate on the proprioception and coordination of young**  
10 **people with Down Syndrome: a two year follow up.**  
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35 **Keywords:** Down Syndrome; karate; martial arts; proprioceptive training; coordination training  
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37 **Word count:** 2316  
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5 **INTRODUCTION**  
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8 Down syndrome is a trisomy in chromosome 21, showing a widely-described phenotypical  
9 variability. With respect to physical activity, it should not be considered as an illness, but rather  
10 as a condition. People with Down syndrome can participate in a diverse range of activities,  
11 provided that these are undertaken in optimal health conditions and without risk for the  
12 individual. From the physiological viewpoint, they are different to subjects without disability in  
13 that they present reduced levels of aerobic metabolism as well as low maximum heart rate  
14 values. Additionally, they demonstrate lower levels of strength. People with this pathology suffer  
15 a pro-oxidative status which contributes to the motor and cognitive deficits particular to this  
16 illness, although this situation can be improved through sport <sup>1</sup>.  
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21 Obesity and excess weight are prevalent among this group. However, few studies have been  
22 carried out on the effect participation in sporting activities has on the weight of Down syndrome  
23 sufferers.  
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26 Physical activity and sport can benefit the physical and motor capacity of these individuals, their  
27 general coordination and fine and gross motor skills, and can improve their balance. Indirectly,  
28 these physical/sporting benefits can contribute to an improvement in social wellbeing and an  
29 enhancement in self-esteem, allowing integration into sporting groups of people without  
30 disabilities.  
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33 No information is available in scientific literature about the improvement in proprioception and/or  
34 coordination in children with Down syndrome with martial art training. Sport, in general, leads to  
35 improvement in proprioception, but no study has been published until now which concentrates  
36 on martial arts.  
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40 The objective of our study is to show that martial arts can have beneficial effects on  
41 proprioception and coordination of upper and lower limbs in teenagers with Down syndrome.  
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## MATERIAL AND METHODS

All the participants had been diagnosed with Down syndrome and regularly attend a centre which promotes integration and autonomy located in the province of Cádiz (Spain). Among other stimulatory and adaptative activities, they performed martial arts, specifically two karate sessions a week. In these sessions, the children with Down syndrome also practised combat techniques (katas) amongst themselves. Throughout the duration of the trial the training was directed by the same instructor, a karate master with considerable experience in teaching karate to both children and adults.

Ten teenagers, ranging in age from 14 to 18, took part in the study. None of the participants suffered from any additional disease which would limit their postural control. Three subjects did not finish the study for family reasons unrelated to the training. All the parents or legal guardians of the teenagers signed an informed consent form in which the objectives and the methodology of the training were explained, along with the details of the investigators and the rights of the parents or legal guardians with respect to the personal information and records obtained about their sons or daughters.

The teenagers participating in the study were evaluated sequentially in postural control before, during and after 2 years of training. Three tests were drawn up to analyze proprioception. The tests chosen and adapted for the study were the following:

(A) **Burpee or Squat Thrust Test:** the participant must carry out a repetitive exercise the most number of times possible in one minute. The exercise consists of five positions, which should be executed correctly and in order, without omitting any, to be considered valid. The positions to be performed are the following: (1) standing position with arms hanging down; (2) the bending of both legs; (3) with the support of both hands on the floor, extending the legs; (4) a further leg flexion and return to the initial position (standing).

(B) **Flamingo Test,** adapted for the special conditions of these participants. For this test the participants had to stand on only one leg, holding the opposite leg, which was bent, with their hands. Initially it was carried out with the right leg and subsequently with the left leg, and the time that each subject was able to remain on only one leg was measured.

(C) **Arm movement speed Test,** consisting in placing two plates 60cm apart and timing the duration of 25 arm movements from one plate to the other. Information was collected for both upper limbs.

A template was designed to record the data, and was transferred to a spreadsheet (openoffice free software) which facilitated the statistical analysis through the free statistical package "R" (<http://www.r-project.org>).

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Images and videos were taken, with the permission of the parents or legal guardians, which enabled us to illustrate the proprioception tests applied to the teenagers, as well as the regular physical activity which they undertook during the period of the study.

The repetition of different measurements in a group of seven individuals was studied, such that the observations are dependent on each other. As the number of participants was small and independent the normality hypothesis could not be guaranteed or tested, so a decision was taken to use non-parametric tests. Hence the Friedman Test is used, which allows us to compare multiple repeated measurements of a test, and whose null hypothesis is the equal of the different subpopulation distributions.

The study was carried out in accordance with the Declaration of Helsinki of 1961 (revised in Edinburgh, 2000), and was approved by the Ethics for Research Committee of the University of Cádiz.

## RESULTS

The results obtained from 7 individuals with Down syndrome, with an average age of 16.3 ( $\pm 1.73$ ), were evaluated. The teenagers improved their results in all the tests carried out to measure their proprioceptive abilities. There were 5 measurements for each test, before, during and after the karate training.

The participants improved in the Burpee test, showing an average initial value of 7.86 repetitions ( $SD \pm 3.85$ ) before the training, and an end value of 16.86 ( $SD \pm 4.26$ ). The Friedman test rejected the equality hypothesis with a p-value of  $p = 0.00044$ . Comparing the initial result with the final one, the equality hypothesis is rejected with a p-value of  $p = 0.0082$  (fig. 1).

The participants also showed positive progress with regard to the speed test, both with the left and the right hands. The improvement in seconds with the left hand was 9.09 ( $SD \pm 4.56$ ), and with the right hand 9.19 ( $SD \pm 3.19$ ), thus not displaying any significant differences in the improvement in both arms. The Friedman test, with regard to the speed of the left arm, rejects the equality hypothesis with a p-value of  $p = 0.0011$ . Comparing the initial situation with the final one, the equality hypothesis is rejected with a p-value of  $p = 0.0082$ . Similarly the Friedman test rejected the equality hypothesis in the right arm with a p-value of  $p = 0.00065$ . Comparing the initial situation with the final one, the equality hypothesis was rejected with a p-value of  $p = 0.0082$ .

The patients improved the times obtained in the Flamingo test significantly in both legs. The average value of the improvement at the beginning of the training in the left leg ( $18.35 \pm sd 8.92$ ) showed no significant differences ( $p = 0.254$ ) from the right leg ( $13.52 \pm sd 9.45$ ). The Friedman test rejected the equality hypothesis in the Flamingo test carried out in both legs, obtaining a p-value in the left leg of 0.0011 and of 0.01121 in the right. Comparing the initial result with the value obtained after the karate training, the equality hypothesis was rejected with a p-value of 0.0082 in the left leg and 0.0082 in the right.

The first and last measurements in the improvement in the results described were compared. However, we would like to highlight the fact that we also detected a significant improvement in the values obtained by the teenagers in the combined comparison of all the measurements taken, which were five in total.

## DISCUSSION

The maintaining of balance and the development of proprioceptive abilities in people with Down Syndrome (DS) are elements of psychomotor development which have been extensively studied<sup>2</sup>. The acquisition of these abilities by means of sport gives parents and teachers a very interesting tool, which additionally enables these individuals to socialize more and lead fuller lives.

Postural control requires two different processes, the first being sensory collecting and organization, and the second motor adjustments. Postural control seems to be well established from 14 years of age<sup>3</sup>, although some authors put it at 10 years of age<sup>4</sup>. This motor ability is limited in patients with DS, specifically in the population which we studied, teenagers and young people<sup>5,6</sup>.

No studies have been carried out on karate as a tool which facilitates the psychomotricity in patients with disabilities. However, constant controlled leg and arm movement is required to be able to execute the particular movements of this sport. This is, therefore, the first study which demonstrates the beneficial effect of karate on young people with DS. We did find numerous publications which use Tai Chi, another martial art, as a method for improving postural control, especially in elderly people<sup>7,8</sup>.

We did not take into account the BMI of the participants as a criterion for selection in the study, dealing in principle with an activity which was open and involved willingness for sporting inclusion. However, the BMI can't be considered as a potential factor of confusion because no participant presented a pathology limited by severe or morbid obesity.

The tests to evaluate balance and coordination had previously been standardized to determine the abilities which interested us, but it was necessary to modify them for adaptation to our patients. The Burpee test requires a good control of posture, and allows evaluation of coordination. This test was designed to measure aerobic resistance indirectly, but it is characterized by requiring coordination and balance to enable the execution of the maximum number of repetitions. The arm movement test evaluates the coordination of the individual. The Flamingo test has been widely used to evaluate proprioceptive ability. Normally it is employed by holding each leg on a wooden board, counting the number of falls of the same over a period of 60 seconds. It was adapted in our case to check the time in seconds during which they were able to maintain the hold. The patients were barefoot to carry out the test, resting the foot directly on the ground. The lack of validation prior to the adaptations carried out could be understood as a distortion in the study. However, the progress in their execution is in itself a reflection of the improvement in coordination and balance in the teenagers studied.

Villaroya et al. compare the static proprioceptive capacity in a group of adolescents affected by DS with a similar group of individuals without DS. For this they use a pressure platform and subject the patients to different situations of opening/closing of the eyes, and foot support on stable/less stable surfaces. They detect a significant reduction of postural control in the group

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with DS. Similarly, they suggest that there is a high dependency of somatosensory input in the individuals affected by DS to maintain their balance <sup>9</sup>. Jankowicz-Szymanska et al. study the impact of physical exercise on the level of static balance in individuals of between 16 and 18 years of age with DS. The calculation of the proprioceptive capacity was verified, in the same way as the other authors, by means of the pressure platform. To improve balance they designed a program which included different somatosensory exercises which stimulated proprioception. After 3 months of training, they concluded that the trained group improved their static balance both with their eyes open and with their eyes closed with respect to the control group <sup>10</sup>. In contrast to ourselves, the authors used a program specifically designed for improving balance. In our case we consider that offering straightforward sporting solutions, such as karate, improves the applicability of clinical investigation in the daily routines of these patients. In addition the cost of sporting equipment, which can be very high, is reduced. Furthermore, the use of simple and easy-to-use tests in the training room facilitates the evaluation of the students.

Nevertheless new trials are necessary, using more sophisticated equipment, which focus on the improvement in coordination and proprioception after doing karate.

In conclusion we would like to underline that the incorporation of karate, and possibly of other martial art disciplines, in the sporting routine of people with DS results in an improvement in their balance and general coordination.

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Figure 1  
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### Burpee Test

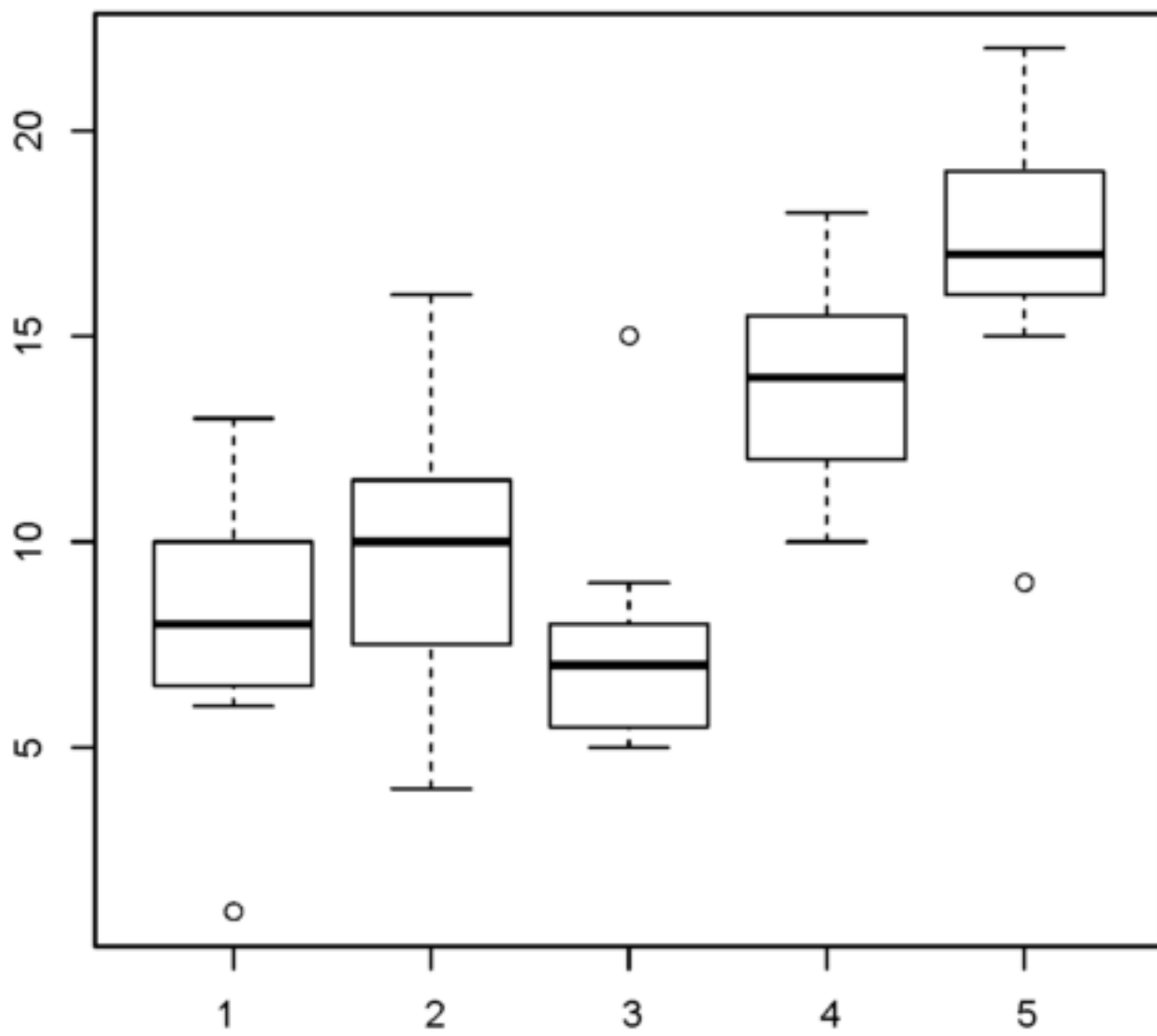


Figure 2  
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### Flamingo left leg

