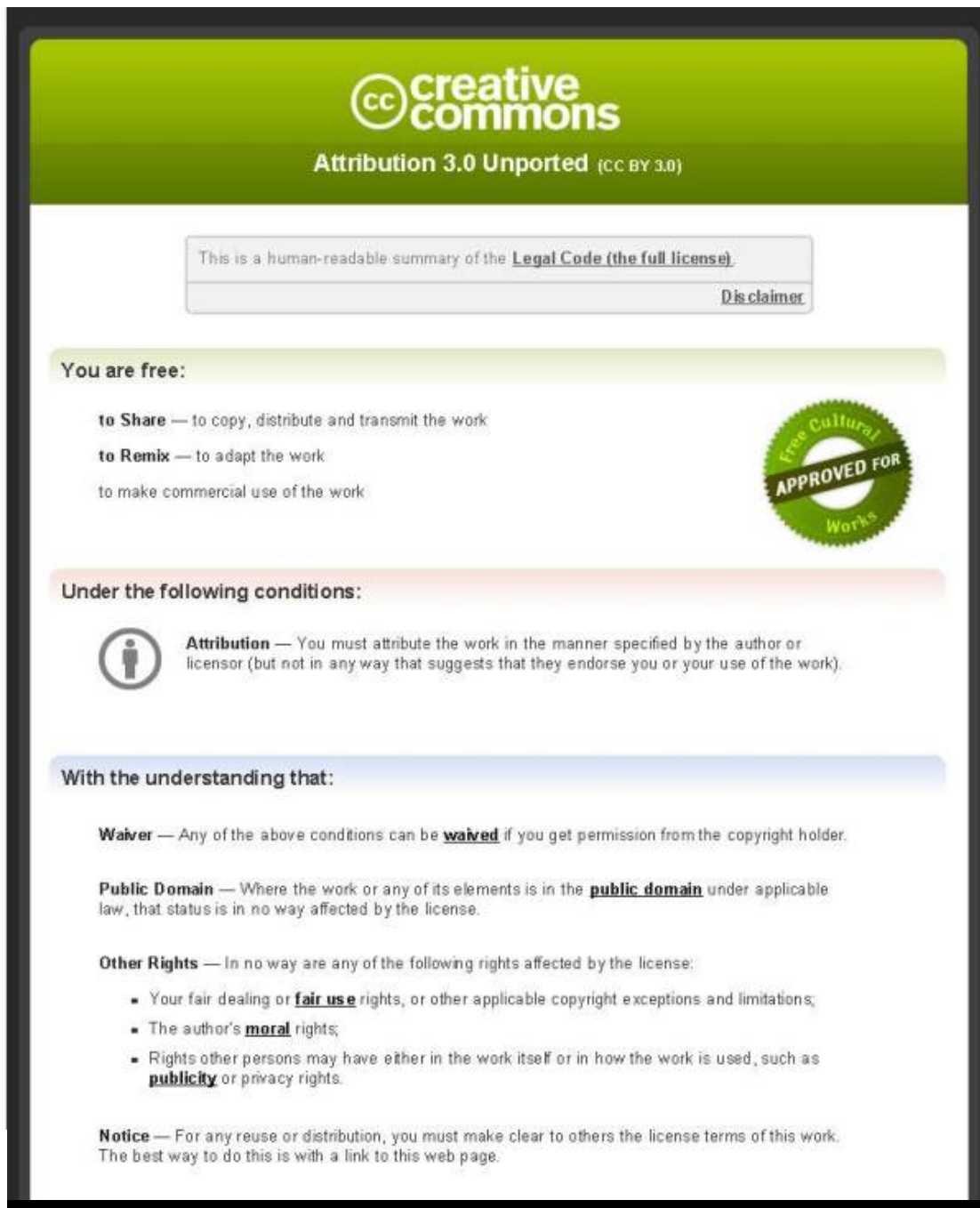




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# Is karate effective in improving postural control?

## Authors' Contribution:

- A** Study Design
- B** Data Collection
- C** Statistical Analysis
- D** Manuscript Preparation
- E** Funds Collection

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## Abstract

### Background and Study Aim:

Performing complex motor skills, such as the ones performed by karate athletes, requires a great sense of balance. Because the posturo-kinetic performance seems to be improved by sport practice, especially by sports involving a lot of posturokinetic activities, the aim of this review was to critically analyse the scientific literature in order to appraise whether any positive correlation between karate and improved postural control is scientifically supported.

### Material/Methods:

The online search engines Scirus and Medline were used for generating the data. A comprehensive literature search was conducted based on the following keywords: “karate”, “postural control” and “body sway”. Results were collected and filtered manually.

### Results:

Four articles were identified related to karate practice and postural control, covering a period between 1998 and 2009. Although different experimental approaches were used to investigate this concept, overall the results of these studies confirm the effectiveness of karate in improving postural control.

### Conclusions:

Practicing karate seems to elicit long term improvements in postural control. However, a much deeper approach to this fighting sport, which would take into account its technical specificities (e.g. kata & kumite), is required in order to increase our understanding of the posture-kinetic impact of this relatively unexplored sport activity.

### Key words:

balance • performance • karate • body sway • kata • kumite

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## BACKGROUND

In humans, the control of balance during upright standing depends upon the central integration of afferent information from vestibular, proprioceptive and visual systems [1]. These systems contribute to postural control and numerous studies have shown that their stimulation evokes body sway [2,3]. In this context, sport training enhances the ability to use somatosensory and otolithic information, which have been demonstrated to improve postural capabilities [4–6]. Compared to non-athletes, athletes such as gymnasts, soccer players, and swimmers have shown to be superior in balance performance during experimental evaluations [7–9]. However,

postural changes are different according to the activity performed and each sport develops specific postural adaptations [6,10]. For example, judo training leads to greater importance being placed on somatosensory information, whereas dance training results in more attention to visual information [11].

The postural adaptations of expert athletes have been demonstrated to be more efficient in terms of sensorimotor control during movements specific to the sport, particularly in combat sport. Elite fighters seem indeed to be superior than non-elite athletes in changing their inter-segmentary coordination in order to accommodate the specific constraints of the task [11].

**Table 1.** Summary of the studies investigating the postural performance of karate athletes.

Title	Author	Year	Factor considered	Participants	Gender	Years of practice	Results	Postural control in karate athletes
"Neural efficiency" of athletes' brain for upright standing: A high-resolution EEG study	Del Percio et al.	2009	Cortical activation during an engaging upright standing	10 karate	M/F	NM	p<0.05	Improved
				10 fencing	M/F	NM		
				12 non-athletes	M/F	NM		
Coupling between punch efficacy and body stability for elite karate	Cesari and Bertuccio	2008	CoP migration; kinematics of the upper limb during punching technique	6 karate	M	NM	p<0.05	Improved
6 non-athletes	M	NM						
Cortical alpha rhythms are correlated with body sway during quiet open-eyes standing in athletes: A high-resolution EEG study	Del Percio et al.	2007	Correlation between cortical activity and body sway during quiet upright standing at open and closed eyes condition	19 karate	M/F	NM	p<0.05	Improved
				18 fencing	M/F	NM		
				10 non-athletes	M/F	NM		
Postural adaptations during specific combative sport movements	Perrot et al.	1998	CoP migration consecutive to frontal punch or frontal kick	17 karate	M	6+	p<0.05	Improved
				11 French boxing	M	NM		

M – male; F – female; NM – not mentioned; CoP – center of pressure.

Karate is a Japanese fighting sport, consisting of repeated sequences of strikes and defences interrupted by recovery periods [12]. Although of a relatively short duration, karate fights are characterized by maximal intensity. The practice of this martial art requires high levels of motor and functional abilities including speed, strength and coordination, in particular balance [13].

Performing complex motor skills, such as the ones performed by karate athletes, requires a great sense of balance. The posture-kinetic performance seems to be improved by sport practice, especially by sports (such as karate) involving a lot of posture-kinetic activities. Furthermore, it has been reported that those activities, improving the postural performance, might be effective in reducing the risk of falling in the elderly population [14]. Therefore, the aim of this review was to critically analyse the scientific literature to appraise whether any relationship between karate practice and improvements in postural control is scientifically supported.

## MATERIAL AND METHODS

A comprehensive literature search was conducted using the online search engines Scirus and Medline. The search was based on the following keywords: "karate", "postural control" and "body sway". Articles and conferences abstracts were checked for relevant content and included based on the following criteria:

1. examined karate performance,
2. examined postural control in sport activities,
3. examined postural control in karate athletes.

Hand searching of the identified papers was used to find other appropriate papers.

## RESULTS

The search resulted in classifying four articles related to postural control in karate, covering a period between 1998 and 2009 (Table 1). The interventions showed two main experimental approaches: the posture-kinetic performance was evaluated in terms of stabilometric and neurological analysis.

Perrot et al. [15] and Cesari and Bertuccio [16] showed that karate seems to benefit postural regulation due to improvements of the individual sensorimotor strategies used to maintain the body' stability. Several karate athletes at different levels were asked to perform specific punching techniques on a force platform. Through a postural control investigation, the centre of pressure (CoP) migration and the kinematic of the upper limbs were analysed. Del Percio et al., in two different studies (2007; 2009), analysed the relationship between cortical activity and body sway in elite athletes (karate and fencing), compared to non-athletes. Authors verified the hypothesis that elite athletes seems being characterized by a reduced alpha task-related power decrease (TRPD) (e.g. cortical activity) during monopodal standing referenced to less engaging bipodalic upright standing. A high-resolution electroencephalography analysis was used to investigate the postural performance during upright standing in open- and closed-eyes conditions. Elite karate and fencing athletes showed a greater "neural efficiency" than non-athlete, as result of the practice of

these sports. Indeed, a reduction in the front parietal neural activation of these fighters was recorded during an engaging upright standing, a finding which was previously observed in subjects with high cognitive skills as well as in other elite athletes [17].

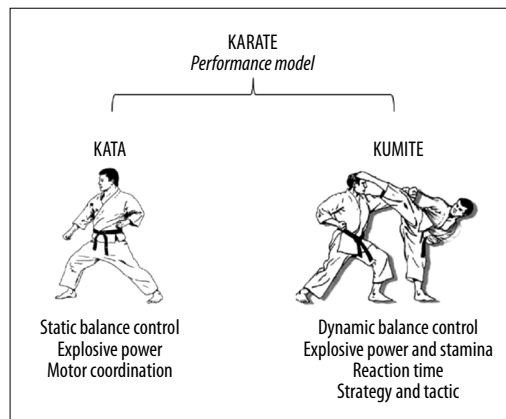
## DISCUSSION

The scientific literature seems supporting the hypothesis of a significant positive correlation between a long-term practice of karate and the improvement of the postural control. These results are aligned with other studies assessing different martial arts. Indeed it has been suggested that martial art experts have a better control of the biomechanical properties of the lower limbs through a more frequent use of the ankle joint than non-athletes [18–21]. Overall, it seems that the practice of combat sports increases the ability to “prepare” the postural adaptations as consequence of a predicted variation in the fighting conditions [11].

However, although the practice of karate seems to produce significant improvements of the body’s ability to respond to external interferences, the limited number of papers and the relatively small samples investigated by these studies (average of  $10.25 \pm 6.13$  participants) make any firm conclusion on this topic difficult to be drawn. Furthermore, almost none of these studies provided any information about the specialisation of the athletes whose posture-kinetic abilities were tested, despite it is well known that elite athletes compete just in a particular speciality at an international level. Only the study by Perrot et al. (1998) briefly highlighted the speciality of the karate athletes selected (two *kata* and two *kumite* competitors). However, the authors did not consider the difference in athletes’ specialization as an inter-individual factor of variability, probably due to the small sample. We found that this aspect needed further clarification.

As modern karate competitions include two specialities, *kata* and *kumite* [22], athletes’ specialisation should be taken into account when their physical qualities are investigated. Indeed, each speciality refers to specific performance models which require a specific training and conditioning.

The *kata* consists of the execution of standardised sequences of offensive and defensive techniques which simulate an imaginary fighting [23]. During *kata* performance, athletes are judged from several criteria, such as correct execution of the sequence, explosive power and balance control. Amongst these, the balance control represents the key determinant of this performance. This coordinative ability is so relevant that athletes are penalised if they show any loss of balance during the execution of the techniques. The quick changes of direction and the large number of technical positions performed during a



**Figure 1.** Karate performance model.

competitive *kata*, represent a challenge to the postural control. For these reasons, it is not surprising that the performance model of a *kata* performer is characterized by an accurate static balance control combined with a highly developed ability of kinesthetic differentiation.

On the other hand, the *kumite* (a score-based, time-limited fight between two opponents) represents the maximal expression of dynamism in karate performance [22]. To be assigned a point, athletes are required to perform percussive techniques to specific striking points (head, trunk and back) as fast and powerful as possible. Fighting against a “real” opponent makes this performance extremely demanding in terms of decision and reaction time. During this fighting competition, the ability to readapt the postural strategies quickly is essential to perform effective offensive and defensive techniques. The *kumite* model is thus more demanding in terms of dynamic balance and postural regulations than *kata*, as it requires the individual technical and physical abilities to be expressed at their best during unpredictable situations. Finally, *kumite* is considered a high intensity intermittent speciality, much more demanding in terms of metabolic power than *kata* [24].

At this point, and in the light of the analysis of performance in karate, it can be suggested that, although either *kata* and *kumite* require high levels of motor skills and high metabolic demands [25], their long term practice and specialization can lead to different sensorimotor and postural adaptations (Figure 1). In support to this concept, anthropological studies investigating karate competitors have suggested that, although a general “karate somatotype” can be identified [26] significant differences within this somatotype can be observed between *kata* and *kumite* athletes, possibly as a result of a specialized practice [27]. Finally, the results of international competitions seems confirming this hypothesis as continental and world champions are most of the time specialised in one of the two specialities.

**Kata** – a standardised sequence of offensive and defensive techniques simulating an imaginary fighting.

**Kumite** – a score-based, time-limited fight between two opponents.

Unfortunately, the studies included in this review did not differentiate the karate athletes according to their specialization, a fact which overall limits our understanding of the impact of each speciality on the postural adaptations resulting from a long term specialized practice.

Although it is well known that the practice of a particular sport produces general short and long term physiological and morphological adaptations, if the sport consists of different competitive specialities, it is critical and appropriate to analyse singularly the impact of each one of them in order to further clarify the relationships between the activity performed and the related physiological adaptations.

## CONCLUSIONS

Practicing karate seems to result in long term improvements in postural control. However, the scientific

literature is lacking of knowledge regarding the specific adaptations resulting by a specialized practice (kata or kumite). Therefore, further studies are needed in order to investigate whether a specialized practice would result in significantly different adaptations in the postural control. Karate is traditionally considered a "high impact sport". However, if e.g. the practice of kata led to significant improvements in balance control in a quicker and safer way than kumite, the value of this martial art could be considered under a different perspective. For example, the practice of kata could be endorsed in the development of new strategies in the fall prevention in the elderly population. This critical public health problem requires support with any relevant, effective and low impact intervention and an adapted practice of karate might represent one of these novel approaches.

## REFERENCES:

1. Del Percio C, Brancucci A, Bergami F et al: Cortical alpha rhythms are correlated with body sway during quiet open-eyes standing in athletes: a high-resolution EEG study. *Neuroimage*, 2007; 36: 822-29
2. Schmid M, Bottaro A, Sozzi S, Schieppati M: Adaptation to continuous perturbation of balance: progressive reduction of postural muscle activity with invariant or increasing oscillations of the center of mass depending on perturbation frequency and vision conditions. *Hum Mov Sci*, 2011; 30: 262-78
3. Peterka RJ: Sensorimotor integration in human postural control. *J Neurophysiol*, 2002; 88: 1097-118
4. Jakobsen MD, Sundstrup E, Krstrup P, Aagaard P: The effect of recreational soccer training and running on postural balance in untrained men. *Eur J Appl Physiol*, 2011; 111: 521-30
5. Biec E, Kuczynski M: Postural control in 13-year-old soccer players. *Eur J Appl Physiol*, 2010; 110: 703-8
6. Paillard T, Noe F, Riviere T et al: Postural performance and strategy in the unipedal stance of soccer players at different levels of competition. *J Athl Train*, 2006; 41: 172-76
7. Ricotti L, Ravaschio A: Break dance significantly increases static balance in 9 years-old soccer players. *Gait Posture*, 2011; 33: 462-65
8. Clary S, Barnes C, Bemben D et al: Effects of ball games, step aerobics, and walking on balance in women aged 50-75 years. *J Sport Sci & Med*, 2006; 5: 390-99
9. Davlin CD: Dynamic balance in high level athletes. *Percept Mot Skills*, 2004; 98: 1171-76
10. Gautier G, Thouvaereq R, Vuillerme N: Postural control and perceptive configuration: influence of expertise in gymnastics. *Gait Posture*, Netherlands, 2008; 28: 46-51
11. Paillard T, Costes-Salon C, Lafont C, Dupui P: Are there differences in postural regulation according to the level of competition in judoists? *Br J Sports Med*, 2002; 36: 304-5
12. Ravier G, Dugue B, Grappe F, Rouillon JD: Impressive anaerobic adaptations in elite karate athletes due to few intensive intermittent sessions added to regular karate training. *Scand J Med Sci Sports*, 2009; 19: 687-94
13. Blazevic S, Katic R, Popovic D: The effect of motor abilities on karate performance. *Coll Antropol*, 2006; 30: 327-33
14. Bulbulian R, Hargan ML: The effect of activity history and current activity on static and dynamic postural balance in older adults. *Physiol Behav*, 2000; 70: 319-25
15. Perrot C, Moes R, Deviterne D, Perrin P: Postural adaptations during specific combative sport movements. *Sci & Sport*, 1998; 13: 64-74
16. Cesari P, Bertucco M: Coupling between punch efficacy and body stability for elite karate. *J Sci Med Sport*, 2008; 11: 353
17. Del Percio C, Babiloni C, Marzano N, et al: "Neural efficiency" of athletes' brain for upright standing: a high-resolution EEG study. *Brain Res Bull*, 2009; 79: 193-200
18. Gorgy O, Vercher JL, Coyle T: How does practise of internal Chinese martial arts influence postural reaction control? *J Sports Sci*. England, 2008; 26: 629-42
19. Rynkiewicz T, Żurek P, Rynkiewicz M et al: The characteristics of the ability to maintain static balance depending on the engagement of visual receptors among the elite sumo wrestlers. *Arch Budo*, 2010; 6(3): 159-64
20. Arslan F, Erkmén N, Taskın H et al: Ankle Joint Position Sense in Male Taekwondo Athletes after Wobble Board Training. *Arch Budo*, 2011; 7(4): 197-201
21. Almansba R, Sterkowicz-Przybycień K, Sterkowicz S et al: Postural balance control ability of visually impaired and unimpaired judoists. *Arch Budo*, 2012; 8(3): 153-58
22. Roschel H, Batista M, Monteiro R et al: Association between neuromuscular tests and kumite performance on the Brazilian Karate National Team. *J Sport Sci & Med*, 2009; 8: 20-24
23. Camomilla V, Sbriccoli P, Di Mario A et al: Comparison of two variants of a Kata technique (Unsu): The neuromechanical point of view. *J Sport Sci & Med*, 2009; 8: 29-35
24. Doria C, Veicsteinas A, Limonta E et al: Energetics of karate (kata and kumite techniques) in top-level athletes. *Eur J Appl Physiol*, 2009; 107: 603-10
25. Nunan D: Development of a sports specific aerobic capacity test for karate - a pilot study. *J Sport Sci & Med*, 2006; (CSSI): 47-53
26. Raschka C, Bouzommita S, Preiss R: Sports-anthropological analysis of Tunisian elite karateka. *Anthropol Anz*, 2005; 63: 415-26
27. Fritzsche J, Raschka C: Sports anthropological investigations on somatotypology of elite karateka. *Anthropol Anz*, 2007; 65: 317-29