Biomechanical methods applied in martial arts studies

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Abstract

Martial arts are practiced in both amateur and in high professional level, stimulating scientific research in several areas of knowledge, including biomechanics. The main purpose of this review is to present the biomechanics methods used in the study of martial arts. The great importance of this study is the compilation of information science of what has already been analyzed under the biomechanics aspects related to martial arts and how this has been done. The methodology was directed to the revision of literature starting from articles, books, and seminars. From the collection of bibliographic surveys, it has been concluded that depending on the parameters studied e.g.: reaction time, speed, strength, power, among others, there is the need to apply one or more methods since there are situations in which only one biomechanical method will not be enough to answer the pointed question. It is also concluded that the investigated studies in the presented review showed the character of a descriptive examination, not directly applied to the development of techniques used on different modalities.

Keywords: martial arts, biomechanics, instrumentation on biomechanics, sport biomechanics, kinesiology.

1 Introduction

Martial arts, nowadays, are practiced by children and adults of both genders, in several societies and with different purpose (DE'VECCHIO and FRANQUINI, 2006). The most practiced modalities involving competitive manner, both professional and amateurs are karate, taekwondo, judo, jiu-jitsu, and kung-fu (CORREIA and FRANCHINI, 2010). The amateur practitioners aim good health and apprenticeship of techniques conceded by the modality, but not the high yield (CARVALHO, 2004). At the professional environment martial arts are practiced as a sporting modality aiming high performance (PIMENTA and MARCHI JUNIOR, 2009).

Some of these modalities such as judo since 1972, in Monique, Germany and the taekwondo since 2000, in Sidney, Australia are considered as Olympic modalities (FALCO, ÁLVARES, CASTILHO et al., 2009; DRIGO, OLIVEIRA and CESANA, 2006). The investments to promote tournaments, mainly connected by television and radio programs surge the interest in the various modalities of martial arts (PIMENTA and MARCHI JUNIOR, 2009). With the professionalism, it became imperative the improvement of the techniques through training (OLIVEIRA, MOREIRA, GODÓY et al., 2006), making it necessary researches which potentially help technicians, coaches and professors of martial arts in planning these trainings in order to give to the athlete the best chance to use his ability completely developed, fully fledged. It is found in the literature biomechanical studies of several modalities that analyze capabilities such as strength, power, reaction time, speed, agility and balance, among other elements. Many of these parameters which had been established are analyzed based on techniques of punching and kicking. These analyses are obtained through biomechanical methods of kinemetry, dynamometry, and electromyography (AMADIO and DUARTE, 1996). Considering the importance of biomechanical parameters of martial arts as a link to improve techniques used, as well as to evaluate performance, the present review aims to exhibit the biomechanical methods used in the studies of martial arts.

2 Material and methods

The PubMed (www.pubmed.nl) and MEDLINE databases were used to conduct a literature search using keywords without restrictions. In this systematization, a search was conducted using the keywords: biomechanics, martial arts.

3 Results

Martial arts are a compound of corporal practices derived from war techniques. The martial term means “Marte – War Roman God” (FRANCHINI, TAKITO, RODRIGUES et al., 1996). The term “art” means expression, invention, imagination, playful and creation (FRANCHINI, TAKITO, RODRIGUES et al., 1996).

As to Reid and Croucher (1983), martial art is a compound of techniques, philosophy and combat traditions. Each martial art is an heiress of a determined tradition and constitutes coherence at all events in a way that all techniques are duly assembled by basic philosophical concepts and by traditional rituals. Martial arts were born many centuries ago aiming high at self defense. The fights among tribes led the warriors to understand the importance of training to face sudden outbreaks in order to get the best results
in the combats (HIRATA and DEL’VECCHIO, 2006). Owing to the big interest in the martial arts by professional practitioners as well as amateurs (PIMENTA and MARCHI JUNIOR, 2009; CARVALHO, 2004), researches are made in this area looking for the best way to improve the combat techniques. Biomechanics has been used through its high methods aiming to study the physics of martial arts.

### 3.1 About biomechanics methods

Biomechanics is one of the sub disciplines of kinesiology (HALL, 2000) and by definition it is the study of the application of mechanics to biological systems (HAMIL and KNUTZEN, 2008). The Biomechanics performance-related areas include measurement and motor control of human locomotion, sports, clinics and rehabilitation, orthopedics, among others (AMADIO and DUARTE, 1996). Biomechanics is structured with areas of cinemetry, dynamometry, anthropometry and electromyography to describe and exhibit a mathematical model of the human movement as a special fact (AMADIO and BARBANTI, 2000; CARPENTER, 2005; WINTER, 1990).

### 3.2 Biomechanical methods used in the studies of physics on martial arts

Biomechanical methods are used in the studies of physics of the martial arts and now some studies will be presented showing how these studies have been made. In a study about karate, Rodrigues and Rodrigues (1984) measured the reaction time and the movement time in the frontal kicks (mae-geri) and circular (mawashi-geri), to check the correlation between these two variables. The results pointed to the fact that independently of the technique used, the reaction time is superior to the movement time Layton (1993) measured the reaction and movement time of four techniques: straight blow (shoki-zuki), reverse blow (gyaku-zuki), frontal kick (mae-geri) and circular kick (mawashi-geri) of karate-shotokan, executed by both sides of the body. The results showed that except for the application of kata techniques the individuals executed the blows within the same reaction and movement time, independently of the side of the body that acts with the technique. Saltzberg, Hondzinski and Flanders (2001) used a system of videos to check five volunteers without any experience on martial arts aiming to describe the process of apprenticeship of an unknown movement involving the whole body. The results showed that the individuals, through practice, changed the angles of torsion and inclination of the trunk, facilitating both the postural and the adjustment of the kicking. Pinto Neto, Magini, Sábba et al. (2008) compared, using a high speed camera (1000 Hz), values of strength, power and efficiency of the palm blow of kung-fu among experienced and amateurs individuals. Viana, Andrade and Belmonte (2005) checked the correlation among the reaction time, flexibility and speed of the lower limbs. The authors concluded that there were not significant positive correlations among the researched variables. Esteves, Nascimento, Moreira et al. (2007), using a triple-axial speedometer coupled together to the back of the ankle of the individual, studied the taekwondo’s kick called bandal tchagui. The results showed that owing to the high sharp of deceleration during the impacts, the structure of the foot becomes susceptible to injuries. Sforza (2002) performed a three dimensional analysis of the karate kicking mae-geri-keage through an optical-electronic instrument. Thirteen reflexive markers were placed on anatomic. The reproducibility of the technique was measured. It was concluded that greater reproducibility was observed in the horizontal plan and it was still noticed smaller deviation in the hip and head. Movements in the ankle and knee joints showed high variability in the dominant member. Nien, Chang and Tang (2007) investigated the effects of speed in the movements of the taekwondo kicking roundhouse in two situations, i.e., kicking a target the quickest possible and repeating the same task without a target. Using a high speed video camera it was concluded that the maximum speed of the toe and the ankle joint considering the existence of a target, was significantly higher than it would be without the target, and further, the angular speed of the hip, knee and ankle did not present significant difference among the situations kicking with or without a target. In these studies the method of cinemetry was used. Pinto Neto and Magini (2008) described the issues of electrical activation of the biceps brachialis, brachioradialis and triceps brachialis muscles as well as the kinematic characteristics of the upper limb during a Kung-fu fight action striking with the palm of the hand. It was observed that individuals did not make total stretching of the elbow at the end of the blow, and the first muscle to be activated was precisely the m. biceps brachialis. The biceps brachialis and brachioradialis muscles displayed less activity before the hand hit the target, whereas the triceps brachialis presented, in this connection to other muscles, larger wideness in the first half of the movement. Castro (1994) compared the action of the biceps brachialis muscle of both the extremity members in the kicking’s dolha chagui and tuit chagui considering 20 athletes of taekwondo black-belt category. For this research he used electromyography aiming to register the electrical activity of the investigated muscles, and also a video-camera to record the kicking’s divided in five phases. The conclusion was that the support limb showed higher muscle activation during striking of dolha chagui compared with tuit chagui kick. Pucsk, Nelson and Ng (2001) analyzed and compared the horizontal and vertical reaction forces of the support leg and the horizontal and vertical speed of the sweeping leg during the execution of the throwing technique (harai-goshi) of judo wrestlers both amateurs and advanced, utilizing a force plate and video cameras. The authors concluded that there was a positive correlation between the horizontal reaction force and horizontal speed of the sweeping leg and a significant difference of the horizontal reaction force of the support leg among beginners and advanced competitors. Fernandes (2009) made biomechanical analysis of the kicking ap bal ap dolio tchagui of taekwondo on 13 elite athletes. In this study the electrical muscle activation pattern for four lower limb and two trunk muscles were identified. It was also measured the electrogoniometry of the knee used for kicking and the horizontal and vertical accelerometry of the lower limb that performed the strike. The results allowed to conclude that all the muscles studied are activated before the movement of the knee, except for the vastus medialis muscle. It was also found that biceps femoris and lateral gastrocnemius are recruited in phase, the left and right erector spinae are pre-activated, maximal knee joint extension occurred approximately 10% of the movement prior to the foot/sand bag contact.
Gorgy, Vercher and Goyle (2008) used force plate in order to study the effect of practicing the Chinese martial arts tai-chi-chuan, pa-koua and shing-hi-chuan in the postural control, using external perturbation with the practitioners in orthostatic position. In the experiment, the force plate was unexpectedly middle-laterally moved. This maneuver was performed with the volunteers keeping the eyes opened or closed. The sample was composed by practitioners of martial arts and practitioners and non-practitioners of sports. It was assayed the center of mass displacement and postural muscles amplitude and onset. It was concluded that the practice of martial arts influence upon the balance, lessening the displacement of the center of mass and pressure, as well as increasing the use of the ankle strategy to deal with the perturbation. However, there were not changes in the temporal patterns of the electromyographic signals of the investigated muscles. Santos, Esteves, Reis et al. (2005) measured the ground reaction forces from judo athletes when applying “ukemies” in different types of surface. Oliveira (2006) identified the palm pressure strength on jiu-jitsu athletes of competitive level using a hydraulic dynamometer and concluded that the jiu-jitsu athletes did not present raised values of palm pressure strength compared with athletes of others martial arts modalities. Borges Junior, Domenech, Silva et al. (2009) compared the maximal isometric palm pressure strength among practitioners of aikido, jiu-jitsu, judo, rowing and non-practitioners. The results showed that there are greater values of maximum strength when the practiced sport is jiu-jitsu, followed by judo, rowing, aikido, and non-practitioners. In this study dynamometry as used. Gulledge and Dapena (2008) compared the ability to unbalance the opponent by applying a direct or a reversal punch. Ground reaction forces, force transducers connected to the opponent body, and digital cameras (to measure kinematic parameters) were used. The results showed that the reverse punch is twice as stronger than the direct punch. However, the direct punch was more efficient considering that the goal was to unbalance the opponent. This is a good example of a complex biomechanical setup used to answer a direct question in martial arts.

4 Conclusion

Owing to the great interest in the martial arts, many researches and developments are carried through biomechanics. The present study proposing a review of the literature aiming the investigation of which biomechanics methods are used in the studies of martial arts, brought the matter forward showing that depending on the variables studied, i.e., reaction time, speed, power, potency, among others, there is the necessity to use one or more methods, since there are situations in which only one biomechanical method is not enough to answer the proposed question. Another question to be pointed out is related to the investigation of existing literature about this subject, as it has not been perceived, that one single variable is more habitually studied than others. It is obvious that each study is concerned at the investigation of its variables, not seeming visible the possibility that one variable may be more important than the other. In relation to the techniques checked, i.e. punch, kicking, balance, among others, it was not also perceived that there are techniques more studied in comparison to others. Another point to be mentioned refers to the fact that most of the studies investigated in this research cover all aspects of purely descriptive research not being directly directed to the development of techniques.

References


