

## Abstract

The continuous development of the martial arts and the inclusion of some of them in the Olympic Games program naturally necessitated a modification of the goals they had previously set themselves. The training process was subject to the transformation laws, in order to give the disciplines a competitive edge. Analysis of sports technique in accordance with the biomechanics principles is the basis of the training process in order to raise the level of sporting sophistication. Moreover, each martial art, in its variety of attack and defence forms, presents completely different execution techniques.

The idea behind the concept of this dissertation? was solving the interdependence issue between the movement pattern of the mae-geri technique and the three phases of physical activity encountered during the training unit from a physiological point of view: before the warm-up, after the warm-up, during the 'shadow battle'.

In addition, the subjects performed the mae-geri technique in two different conditions, more utilitarian, on a target, whose movement as a visual-triggered signal was recorded by an accelerometer. The second option was to kick in the air in a kata formula, at their individual pace. A novice-expert paradigm was used to assess differences in the mastery of the movement pattern of the mae-geri kick depending on the level of sporting proficiency. As a novel concept, the use at the same time of integrated systems was proposed: motion capture based on inertial sensors and surface electromyography (sEMG). In the first case, biokinematic computer models based on a standardized calibration were created. The studied technique was then recorded with the possibility of calculating biokinematic indicators based on EMG and IMU.

The study was conducted at the Faculty of Physical Education and Physiotherapy of the University of Technology in Opole in the laboratory of anthropometrics and biomechanics. The study group [N = 28] consisted of advanced karate kyokushin athletes (from 3 kyu – green belt - upwards, N = 13) the control group of intermediate athletes (from 6 to 4 kyu, N = 15). The results of both groups were averaged and compared with each other.

The results indicate that the conditions applied, affect movement and reaction time in both groups. Warm-up tasks prior to hitting the air in both groups reduced the execution time of the mae-geri. In addition, the advanced group showed statistical significance at  $p = 0.035$ , indicating the need to activate the skeletal and muscular apparatus to an optimal level and a high awareness of pre-injury prevention. Reaction time results did not show statistical significance between groups but did show a trend where the advanced group reduced reaction time in successively applied conditions. Warm-up, 'shadow fighting' and hitting the target are

conditions close to the reality of training or fighting an opponent, where athletes reach an optimal state of muscle fibre activation.

The results of the lower limb kinematics analysis showed no significant statistical differences between the groups. On the other hand, several trends that may affect the performance of the mae-geri kick were observed. The group of advanced karate practitioners kept the thigh and shin segments aligned during the air and target kick, while the others rotated the knee joint (shin) outwards. This action has the effect of adding up ligament and muscle micro-injuries, which, when combined with high force, can result in a sprained joint or a tear or rupture of ligaments and muscles. In addition, it has been observed that advanced karateka athletes straighten the knee joint less when kicking in the air compared to the intermediate group. Such an action is a protection of the knee from avulsion damage, during the vigorous "throwing" of the foot into the air. On the other hand, during the kick to the target, it was the expert group who straightened the knee joint more and flexed the sole of the foot in order to obtain more force, which they transferred to the target.

The results of muscle bioelectrical activity in terms of %MVC showed that the intermediate group, during the mae-geri kick, engaged the soleus muscle more for plantar flexion of the foot than the advanced group. The experts, on the other hand, engaged the gastrocnemius muscle to a greater extent, which, as is well known, is a muscle composed predominantly of fast-contracting fibres, which, combined with its large mass, will ensure the generation of greater forces. In addition, a trend was observed in which the advanced used the vastus lateralis muscle more during the shield kick as a strong extensor of the knee joint. This action demonstrates the finishing of the movement and the maximum straighten of the knee, which, combined with greater soleus flexion and gastrocnemius muscle activity, will allow the generation of greater power in the mae-geri kick.

The combination of the sEMG and IMU systems enables a comprehensive assessment of the activity of selected muscles and the movement trajectory of the mae-geri kick. Such knowledge, already at the beginning of training in kyokushin karate or other martial arts, makes it possible to eliminate incorrect movement patterns and can shorten the time to achieving a master class.

In addition, an accurate analysis of body positioning or the movement trajectory of limb segments in space makes it possible to prevent injuries. In summary, both systems can serve as a tool for monitoring athletes and modifying training units in terms of muscular and kinematic activity.