IDO – Ruch dla kultury / Movement for Culture
2010, vol. 10, no. 1

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Scientific Approaches to Olympic Taekwondo: Research Trends / Naukowe ujęcia olimpijskiego taekwondo – kierunki badań

Submission: 15.10.2009, acceptance: 30.12.2009.

Key words: performance, laboratory evaluation, field evaluation

Abstract/summary: Originating from an ancient martial art, taekwondo recently entered the Olympic Games. Over the last decade, there has been a growth in research directly related to Olympic taekwondo, indicating an increased interest of sport scientists who approached this sport from several perspectives. Although most of this research is focused on injuries, there has been a steady increase in publications related to the anthropometric and fitness profiles of athletes. In recognition of the important role played by the optimal physical preparation of elite, most recent field studies made use of technological developments capable of quickly measuring the athletes' physical performance and monitoring their responses to competition. This panoramic review highlights areas that require further exploration, aiming to increase the awareness of both coaches and researchers of the various aspect of this combat sport. It is a challenge to those specializing in science and taekwondo to contribute to the development of a multidisciplinary approach to the evaluation of the complexity of the taekwondo performance.

Introduction

Taekwondo entered the Olympics in Sydney 2000, representing with judo the only two "oriental" sports of the Games. This combat sport aims to develop specific technical skills, physical fitness, and psychological well-being [World Taekwondo Federation 2008], educating also self-discipline, self-control, and respect for others in practitioners [Pieter & Heijmans 2000; Skelton *et al.* 1991; Yard *et al.* 2007]. Competitions are regularly organized at regional, national and international levels according to the athlete's age, skill level (i.e, belt color), and weight category. Official competitions include qualifying, semi-final and final phases organized during the same day with a variable time schedule (i.e., 30-120 minutes between competitions). Therefore, successful athletes might engage in several matches before their final one. A single match comprises three 2-minute rounds with a 1-minute rest in between and points are scored when an athlete produces a displacement of his/her opponent's body segment punching his/her torso or kicking his/her torso and head (World Taekwondo Federation, 2008). Since taekwondo athletes start training and competing around 10 years of age (own observations), more stringent rules for scoring area (i.e., only torso), protective garments (i.e., head and chest protection, arm and shin pads, groin protectors and mouthguards), and match duration are applied to competitions for children.

Taekwondo and health

In the last decade, the interest in developing and preparing talented athletes urged scientists to investigate several aspects of taekwondo, which is relatively new for sport scholars. Being a combat sport, taekwondo players might be exposed to a substantial risk of sustaining injuries. Thus, it is not surprising that most of the studies have focused on sport-related injuries [Beis *et al.* 2001; Chuang & Lieu 1992; Feehan & Waller 1995; Gong *et al.* 2007; Junge *et al.*2009; Kazemi & Pieter 2004; Kazemi & Shearer 2008; Kazemi *et al.* 2005; Keçeci *et al.* 2005; Koh & Cassidy 2004; Koh *et al.* 2003, 2004; Lee *et al.* 2009; Lystad *et al.* 2008; Maffulli *et al.* 1996; Pary & Rodnitzky 2003; Pieter 2005; Pieter & Zemper 1997, 1998, 1999; Koh & Watkinson 2002;

Serina & Lieu 1991; Shin *et al.* 2008; Siana *et al.* 1986; Yard *et al.* 2007; Yeadon 1992; Zemper & Pieter 1989; Woodward 2009] to understand specific patterns that may assist with the development of discipline-specific preventive interventions of this combat sport.

Reviewing the effects of martial arts practice on health, several authors [Lystad *et al.* 2008; Woodward 2009] claimed that taekwondo is relatively safe compared to many other sports, and the majority of injuries appear to be of minimal severity. In particular, reporting on the occurrence of injuries in young (i.e., 6-17 years) American judo, karate and taekwondo athletes, Yard and colleagues [2007] attributed most (80%) of the injuries to karate, whereas taekwondo practitioners sustained significantly lower proportions be sure to indicate the design of the studies on which this conclusion is based; proportions do not take into account exposure to injury, which may lead to erroneous conclusions of neck and shoulder/upper arm injuries than their Judo counterparts. These results indicate that the correct execution of sport-specific techniques and the protective garments are effective preventing tools for taekwondo practitioners. However, coaches should place a particular attention to those athletes whose skill level is not fully developed prior to exposing them to competitive fights [Koh *et al.* 2004].

From laboratory to field evaluations

One research area made use of traditional laboratory approaches to evaluate the physical fitness characteristics of athletes and the executions of technical skills [Kazemi *et al.* 2006, 2009; Markovic *et al.* 2005; Melhim 2001; Pieter & Pieter 1995; Toskovic *et al.* 2004; Cetin *et al.* 2009; Davalli *et al.* 2008; Falco *et al.* 2009]. Compared to non-winners, successful athletes are taller and thinner [Kazemi *et al.* 2009], and show better power and agility performances [Markovic *et al.* 2005; Melhim 2001]. Considering that points are scored using kicking techniques [Kazemi *et al.* 2009], tall and thin athletes are advantaged because they maintain a shorter opponent at a greater distance and have a favourable weight-to-strength ratio, which is crucial for all-out jumping performances.

Although anthropometric and fitness variables influence the technical and tactical aspects of a match, there is not a straightforward relationship between the individual characteristics and the achievement of success in a championship. Taekwondo being a construct in that a multitude of different performance indicators interact, the acyclic patterns of the match are neither agreeable to time-series analysis nor compatible with the traditional models of studying exercise in laboratory conditions. In particular, the interpretation of laboratory findings might lead to misleading representation of the relevant aspects of the actual load of taekwondo matches and training sessions, especially when experimental settings include participants with a limited experience and make use of unrealistic types and number of actions, questionable intensities of exercise and work-to-rest ratios, and different recovery interventions. In fact, taekwondo performances take place under a high situational unpredictability due to the interaction of the players with their competitive or training environments. During matches, physiological, technical, tactical, biomechanical, cognitive and psychological stressors determine several activity profiles in relation to the proficiency and the age of the athletes. Therefore, sport scientists have an arduous goal in evaluating the different demands of taekwondo to give a reasonable prediction of such a variable performance or to provide specific exercise models. Surely, examining athletes during their actual training and match play might increase the relevance and the applicability of the results. Thus, there is a need of field evaluations that maintain the experimental control and incorporate several practical aspects of this sport.

Recently, physiological responses to training [Bridge *et al.* 2007; Jakubiak & Saunders 2008; Pieter & Heijmans 2000] and simulated competitions [Bouhlel *et al.* 2006; Boutios & Tasika 2007] have been studied. More than training, competition proved to be a challenging situation, stimulating higher psycho-physiological responses in the participants [Bouhlel *et al.* 2006; Bridge *et al.* 2007; Chiodo *et al.* in press a, b]. Even though the rules of taekwondo severely restrict the opportunities of data collection and the hectic atmosphere that exists during a competition generally does not promote the cooperation of athletes to participate in experimental settings under competitive conditions, the recent availability of non-invasive light-weight equipment (i.e., heart rate monitors with internal memory, portable blood lactate, saliva collectors, and questionnaires) and the cooperation with National Taekwondo Federations allowed several measurements on athletes during official elite [Bridge *et al.* 2009; Chiodo *et al.* in press a] and youth [Casolino *et al.* 2009; Chiodo *et al.* 2007, in press b] taekwondo competitions.

The research showed that the exercise load of both simulated and official taekwondo competitions elicited high heart rate responses and blood lactate values, indicating the dominant involvement of the anaerobic metabolism [Bouhlel *et al.* 2006;

Chiodo *et al.,* in press a]. Findings also indicated that elite athletes, alternating all-out performances with sufficient active recovery, tend to save their energy for the last periods of the competition when most frequently decisive attacks occur. In fact, the neuromuscular function of lower limbs primarily used by the athlete to score points [Kazemi *et al.* 2006, 2009] resulted in enhanced performance at the end of the match, whereas a significant reduction of upper limb strength has been observed [Chiodo *et al.,* in press a]. The authors attributed these findings to the effects of repeated contusions on the upper limbs used to protect from the opponent's kicks and punches directed toward the scoring area. This information collected during official competitions provides a series of useful indications to assist coaches in the optimization of sport-specific training programs. In particular, coaches are urged to improve the upper limb strength [Chiodo *et al.,* in press a] and appropriate/practical upper limb blocking skills as well as evasive movements of their athletes [Koh *et al.* 2004]. Koh et al.'s recommendation was based on their injury research in light of injury prevention. However, you are relating upper limb strength to performance. The relationship between upper body strength and performance has not sufficiently been investigated yet. My own teams have done preliminary research on this relationship and found that upper body strength and endurance did not predict performance.

Although taekwondo aims to maximize the athletes' potential, teaching them to control their aggressive behaviour [Skelton *et al.* 1991], precompetition anxiety level [Chapman *et al.* 1997; Cerin 2003], and mood responses [Chiodo *et al.,* in press b; Pieter & Heijmans 2000; Toskovic 2001] to taekwondo training and competition is relatively scarce. Although the optimum level of the mood dimensions could be highly individualized, in general taekwondo athletes show positive mood patterns, which could be modified as a result of intense training [Pieter & Heijmans 2000] or competition [Chiodo *et al.,* in press b]. Thus, monitoring mood state of the athletes could be a precious tool for coaches to prevent maladaptations to training, which could lead to non-functional overreaching [Pieter & Heijmans 2000]. Furthermore, there is a need for further studies on the evolution of mood responses during the day of competition to verify whether taekwondo athletes experience cumulative psychological stress progressing toward the final match. This information might be also particularly relevant for coaches who might consider monitoring mood state appropriate to adopt effective recovery strategies for their athletes [Pieter & Heijmans 2000]. Furthermore, considering that prior to competition successful taekwondo athletes reported lower cognitive and somatic anxiety and higher self-confidence than those who lost [Chapman *et al.* 1997], the evaluation of the athlete's psychological responses to competition could be crucial to implement systematic psychological training and counseling.

The young athlete

The physiological load and the technical aspects of taekwondo competitions vary in relation to the age and technical level of the athletes [Bridge *et al.* 2007; Toskovic *et al.* 2009], so that it is not possible to generalize information gathered on elite athletes to young ones. Despite competitions being organized for children (i.e., >10 years of age), little information is available on youth taekwondo [Casolino *et al.* 2009; Chiodo *et al.,* in press b; Melhim 2001]. Recent findings indicate that youth matches elicit high heart rate and hormonal responses in young competitors. However, situational and contextual factors vary considerably between matches played by young and elite athletes. In particular, it would be interesting to study peculiar aspects of sport-specific skills to generate proper strategies to facilitate the learning process. Because taekwondo competitors must be able to move with high velocity, speed, and power, research on technical skills could greatly benefit from biomechanical analysis. Although stereophotogrammetry could provide an accurate measure of the instantaneous acceleration of the body segments during the execution of different techiques [Davalli *et al.* 2008], the high cost of the instrumentation, the restricted portability, and the need for elaborate data reduction limit its use to skilled experimenters and laboratory settings. In field evaluations, coaches and scholars could make use of portable inertial measurement units, containing a 3D accelerometer and a 3D gyroscope, for the assessment of specific taekwondo performances. Furthermore, coaches might gather significant indications from notational and match analyses, which might include a wide multiplicity of movement patterns and decision-making about opportunities to become engaged in attacks. Definitely, these data could provide advances in the understanding of this sport and guidance for applied practice.

Conclusions

Taekwondo performance could greatly benefit from an ecological and multidimensional research ap-

proach, interfacing the demands of matches and training, and the capabilities of athletes. In view of the need for information on real-life sport settings, a high ecological validity and a strict control of variables is essential. Future work should offer a multidimensional (i.e., physiological, psychological and technical-tactical) approach to the study of the "situational" aspects of taekwondo performances that incorporate unorthodox patterns of movements and specific skills. The authors hope that this review will stimulate research on taekwondo and bridge the gap between scholars and coaches, with the aim of increasing the quantity and quality of information on this combat sport.

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Słowa kluczowe: wyczyn, ocena laboratoryjna, ocena polowa

Streszczenie: Pochodzące od dawnych sztuk walki taekwondo od niedawna jest sportem olimpijskim. W ostatniej dekadzie nastąpił rozwój badań bezpośrednio związanych z olimpijskim taekwondo, wskazujący na wzrost zainteresowania specjalistów nauk o sporcie, którzy podchodzą do tego sportu z kilku perspektyw. Chociaż większa część badaczy skupia uwagę na urazach sportowych, stale wzrasta ilość publikacji związanych z antropomotoryką i profilami sprawności sportowców. W uznaniu istotnej roli odgrywanej przez optymalne fizyczne przygotowywanie elity, najnowszy obszar badań skorzystał z technologicznego rozwoju umożliwiającego szybki pomiar działania sportowca i kontrolę jego przygotowania do zawodów. Ten panoramiczny przegląd wysuwa na pierwszy plan przestrzenie, które wymagają dalszych badań dla lepszego rozumienia rozmaitych aspektów tego sportu walki przez badaczy i trenerów. To jest wyzwaniem dla naukowców i specjalistów od taekwondo, by przyczyniać się do rozwoju multidyscyplinarnego podejścia do kompleksowej oceny wyczynu sportowego w taekwondo.