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ORIGINAL

MOTOR DIFFERENCES IN CADET TAEKWONDO ATHLETES ACCORDING TO COMPETITION LEVEL

DIFERENCIAS MOTORAS EN ATLETAS CADETES DE TAEKWONDO SEGÚN NIVEL COMPETITIVO

De la Fuente, A.¹ y Gómez-Landero Rodríguez, L.A.²

¹ Club Deportivo CDE Sánchez Élez-Sanabria. España. ana.delafuente@hotmail.com

² Universidad Pablo de Olavide. Facultad del Deporte. España. lagomrod@upo.es

Spanish-English translators: Laura Rosillo Beneyto, e-mail: laurarosillobeneyto@gmail.com, Universidad de Alicante.

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ABSTRACT

The aim of this study was to observe the differences between Taekwondo cadet athletes belonging to different competition levels in terms of anthropometry, legs power, flexibility and reaction time. Twenty male athletes were analysed, divided in two groups: national medallist and non-national medallist. Data of every athlete's anthropometric measurements, reaction speed ability, leg power and hip ROM (range of movement) were taken. Medallist athletes showed significantly lower values for height, arm span, foot reaction time (dominant and non-dominant) and non-dominant hand reaction time; and higher values for leg length, passive hip flexion, active hip abduction and passive hip abduction in ROM tests. Slight differences observed between medallists and non-medallists in leg power (CMJ), body fat (Σ skinfolds) and active hip flexion don't agree with previous studies. Knowing this information could be interesting for coaches in order to carry out talent detection programmes.

KEY WORDS: Taekwondo, combat sport, performance, talent detection, competitive profile.

RESUMEN

El objetivo de este estudio es observar las diferencias entre atletas cadetes de Taekwondo de diferentes niveles competitivos en términos antropométricos, de potencia muscular, flexibilidad y velocidad de reacción. Veinte atletas varones fueron analizados, divididos en dos grupos: medallistas nacionales y no medallistas nacionales. Para cada atleta se tomaron datos antropométricos, de velocidad de reacción, potencia muscular y rango de movimiento articular de la articulación coxofemoral. Los atletas medallistas mostraron valores significativamente menores en altura, envergadura, tiempo de reacción óculo-podal, y tiempo de reacción óculo-manual con mano no dominante; y valores mayores para longitud de piernas, flexión pasiva de cadera, y abducción de cadera tanto activa como pasiva. Las leves diferencias observadas entre grupos en potencia muscular, grasa corporal y flexión activa de cadera no concuerdan con estudios previos. Conocer esta información podría ser de interés para los entrenadores para llevar a cabo programas de detección de talentos.

PALABRAS CLAVE: Taekwondo, deporte de combate, rendimiento, detección de talentos, perfil competitivo.

INTRODUCTION

Nowadays, taekwondo (TKD) is an Olympic combat sport whose competition events are regularly organised the regional, national and international level according to the athletes' age, sex and weight category. According to World Taekwondo Federation (WTF) rules, (World Taekwondo Federation, 2016), athletes must obtain more points than their opponent by executing valid kicking and punching techniques on the permitted scoring areas, or by a technical knockout, during a match of three 2-min rounds with a 1-min rest interval between them.

In sports, talent identification is essential for the early guidance and training of athletes. However, determining the performance-specific factors of each sport is first necessary for the talent detection process. In TKD, the cadet category (12- to 14-year-old athletes) was the first age category internationally recognised for official competition (WTF, 2016). Cadet championships have the same structure and characteristics as senior ones, so it is a sensible stage for talent identification.

Poor references have been found in the scientific literature about performance factors among cadet TKD athletes. Anthropometric measurements, such as height or extremity length, have been identified as success variables in TKD, according to the idea that longer upper limbs provide a greater ability to cover a larger area with less energy in the defensive blocking actions, and longer lower

limbs become a longer lever to generate more power in offensive kicking techniques (Kazemi et al., 2006; Markovic et al., 2005). Other anthropometric factors like body composition are also decisive for TKD competition as categories are divided by weight so that it is desirable for athletes to achieve the minimal percentage of fat mass compared to muscle mass so as to optimise the power-to-weight ratio (Bridge et al., 2014). The ballistic nature of the kicking techniques requires an explosive leg, especially for leg extensors (Kazemi et al., 2006; Suzana & Pieter, 2009). Flexibility, defined as the range of motion (ROM), is an ability particularly needed in TKD because the kicking techniques, especially those guided to the head, require a large hip joint ROM of the hip joint for their execution (Bridge et al., 2014; Suzana & Pieter, 2009). Reaction time also seems important as success in achieving scoring depends greatly on the execution time of a technique, hindering an opponent's blocking action in order to block an attack.

The importance of these variables has been demonstrated for junior and senior athletes' success in TKD competition (Bridge et al., 2014; Gaeini et al., 2009; Kim et al., 2010; Plon et al., 2014). For body composition, previous studies by Sadowski et al. (2005), Kazemi et al. (2006), Markovic et al. (2005) and Pieter (2008) reported a lower fat mass percentage in athletes with higher levels of competitive success than their national-level counterparts; all the studies analysed both junior and senior athletes. There is some evidence that a higher limb length could support better competitive performance in TKD (Kazemi et al., 2006; Sadowski et al., 2012). In previous research in similar disciplines, such as karate or mixed martial arts (Balsalobre et al., 2012; Marinho et al., 2011), some studies, such as those of Markovic et al. (2005), Casolino et al. (2012) and Chiodo et al. (2011), have reported a higher leg explosive strength (measured using Countermovement Jump, CMJ) for international senior TKD athletes, compared with their national counterparts. Studies which have evaluated flexibility using the extended sit-and-reach test have concluded that, although it may be important for TKD performance, it is not a variable to discriminate athletes from achieving different competition levels of success (Bridge et al., 2014; Kazemi et al., 2006). Nevertheless, more research using the angular ROM test is needed, because these tests show a closer relation with specific actions (Bridge et al., 2014). Regarding the reaction time, and according to the data reported by Fontani et al. (2006) for karate athletes, a significantly lower reaction time has been observed in senior athletes of the national team in comparison with senior athletes at recreational level, and these data may be similar in TKD because of the likeness between the disciplines. Nevertheless, more research is needed in earlier age categories to determine which characteristics predict competitive success at young ages; however, it seems that all the determinant characteristics for junior and senior athletes will also be important for earlier ages.

Considering all the above factors, the aim of this study was to compare data obtained from the variables of anthropometry, leg power, flexibility and reaction time in TKD cadet athletes, in order to observe if there are differences between the values of athletes at different competition levels of success; and whether these variables are determinant for competitive success because of sport characteristics and according to the data for junior and senior athletes.

MATERIALS AND METHODS

Participants

Twenty male TKD athletes between 14 and 15 years old (all born in the same year) were studied once their last year as cadet athletes had just finished. All the subjects had more than four years' experience in official championships. These athletes were members of different clubs in Madrid and also part of its official regional team. They represent all the combat competitors of this age in this region. According to official national competition results, the cadet athletes were divided into two groups: medallists (n=8) and non-medallists (n=12). All the subjects and their legal guardians signed a written informed consent, in accordance with the procedures and the publication of the data. Ethical approval for this research was obtained from the University's Human Research Ethics Committee.

Measures

Anthropometric measurements were collected according to the rules of the International Society for the Advancement of Kinanthropometry (ISAK) (Marfell-Jones et al., 2006). Six skinfolds were measured: triceps, subscapular, abdominal, suprailiac, mid-thigh and calf. The summation of these six skinfolds is the variable used for the analysis.

Reaction time was measured using the eye-foot reaction test proposed by Padaguan (2014), fully replicated for eye-foot reaction time and lightly modified for eye-hand reaction time measures. The Chronojump-Boscosystem contact mechanism was used for both, connecting the time controller hardware (Chronopic 3) to the laptop and to two contact devices for each test. For the eye-hand reaction test, Chronopic 3 was connected to two buttons, one for the researcher and the other for the subject. When the researcher held the button, the LED light in Chronopic 3 was off; when he released it, the LED light switched on and the subject had to press the button as fast as possible. The athlete was sitting on a chair in front of a table, putting his hand on a mark 5.08 cm from the button. Three trials with a 30-second rest period between them were performed to allow subjects to become used to it, and after another 30-second-rest period, three executions with a rest period between each were performed to collect data. The average of these three executions was used as a variable of analysis. The same procedure was followed for the other hand. If any execution was technically wrong, it was repeated.

For the eye-foot reaction test, the development was the same, but using a contact platform instead of a button. The athlete was standing with his foot on a mark 10.16 cm from the platform, keeping both heels on the floor. Upon watching the visual stimulus (the LED light from Chronopic 3) activated by the tester, the participant stepped onto the platform with his front foot as fast as possible. Three trials and three executions with a rest period between each

were performed. The average of the executions was used as a variable of analysis. If any execution was technically wrong, it was repeated.

Leg power was measured by CMJ, using the Chronojump-Boscosystem contact platform. Two familiarisation trials were permitted, after which three test executions were carried out, with a 1-minute rest period between each trial and real jump. If any execution was technically wrong, it was repeated. The maximum height reached in these three executions was used for the analysis.

For the hip ROM measures, two tests were used: straight leg raise and abduction from a 90° flexion. Both active and passive variables were accomplished in both tests, and the two legs (dominant and non-dominant) were analysed. In the straight leg raise test, the subject had to be in a supine position, leg extended, with his trunk and head in contact with the floor, raising his leg in a straight position to the maximum height possible. For the abduction from a 90° flexion test, the subject had to be in a supine position, in a 90° hip flexion, legs extended and with his gluteal region against the wall in order to abduct his legs as much as possible. Stickers were placed at important anatomical points for subjects: trochanter, external malleolus and internal malleolus for the straight leg raise test; and the pubis and the middle point of the intermalleolar line for abduction from the 90° flexion test. Placing a camera 3 metres from subjects, images were taken from each execution; if any execution was technically wrong, it was repeated. ROM in both tests was analysed by using *Kinovea*® image software, drawing angles by using marked points.

Procedures

The subjects were evaluated in a single session using the battery of tests and protocols described. The evaluation session lasted approximately one hour, and a 10-minute rest period separated one test from the next. All participants were active competitors in combat (Olympic) modality, and were also in their first months as junior athletes. They had thus recently finished their career in the cadet category and their full success could be analysed. The participants had to have had four years' competition experience in order to guarantee they had fought in official championships as their first year in the cadet category.

First of all, in each session, participants were informed about the study's aim and the test planning and development. The athletes were told to avoid physical activity for 24 hours before the tests, and for a period of at least three days after the last competition. Data collection was performed personally by the authors in the following order: 1) anthropometric measurements (height, arm span, leg length and skinfold - six - to infer the body fat percentage); 2) eye-hand reaction test (EHRT); 3) eye-foot reaction test (EFRT); 4) CMJ; 5) hip ROM. Before the reaction tests, the athletes performed a standard warm-up for ten minutes, consisting of jogging and different steps, but were instructed not to do any stretching exercise. Before the CMJ test, the evaluators explained in detail the technique to execute the jump, and the subjects performed another warm-up specific to this test, consisting of two series of 10 CMJ jumps, leaving a one-minute rest period between each series. Before the hip ROM test, the

participants were instructed to perform another specific warm-up consisting of stretching for ten minutes and ROM exercises for the hip joint.

Statistical Analyses

Data collected for each variable were compared between groups: medallists and non-medallists. The comparison between parametric values was determined by Student's T-test for independent samples distribution analysis. Mann-Whitney's U test was used for variables with non-parametric characteristics. The level of significance was set at $t = 0.5$. Data are reported as descriptive statistics, average \pm SD.

Comparison between the number of techniques in skinfold measurement and reaction test data was made by the repeated-measures analysis of variance proposed by Hopkins (2000a; 2000b), using Intraclass Correlation Coefficient (ICC) for skinfolds and Coefficient of Variation (CV) for reaction time measurements. All values of ICC for skinfolds were higher than 0.98, which means measurements have a very high reliability according to Vincent (1999). All values of CV in reaction time measurements are lower than 7.1%, which means that these measurements are also very reliable according to Atkinson et al. (1999).

RESULTS

Significant ($p < 0.05$) main effects from Student's T and Mann-Whitney's U testing were reported for all variables measured in the present study and are shown in Table 1.

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Table 1. Comparison of study variables by results level.

| Variable | Medallist | Non-medallist | Effect Size (<i>d</i>) |
|--|----------------|------------------|--------------------------|
| Height ^t | 163.188 ± 6.12 | 168.958 ± 4.83* | -1.074 |
| Arm span ^t | 163.25 ± 5.23 | 172.833 ± 6.95* | -1.558 |
| Leg length (absolute) ^t | 84.438 ± 5.90 | 83.667 ± 4.00 | 0.153 |
| Leg length (% total height) ^t | 51.388 ± 2.19 | 49.507 ± 1.53* | 0.996 |
| Σ skinfolds ^u | 53.549 ± 20.06 | 52.468 ± 26.93 | 0.046 |
| CMJ ^t | 32.042 ± 4.85 | 27.185 ± 8.01 | 0.734 |
| EHRT | | | |
| Dominant hand ^t | 0.386 ± 0.02 | 0.419 ± 0.05 | -0.867 |
| Non-dominant hand ^t | 0.401 ± 0.02 | 0.451 ± 0.06* | -1.118 |
| EFRT | | | |
| Dominant foot ^t | 0.422 ± 0.02 | 0.475 ± 0.04* | -1.676 |
| Non-dominant foot ^t | 0.434 ± 0.03 | 0.507 ± 0.04* | -2.065 |
| Active Straight Leg Raise | | | |
| Dominant leg ^t | 83.63 ± 9.21 | 78.75 ± 15.27 | 0.784 |
| Non-dominant leg ^t | 77 ± 11.19 | 67.08 ± 17.17 | 0.685 |
| Mean two legs ^t | 80.313 ± 9.79 | 71.25 ± 14.80 | 0.722 |
| Passive Straight Leg Raise | | | |
| Dominant leg ^u | 115.25 ± 15.25 | 90.92 ± 20.50* | 1.347 |
| Non-dominant leg ^t | 110.25 ± 16.20 | 84.33 ± 20.96* | 1.384 |
| Mean two legs ^t | 112.75 ± 15.59 | 87.625 ± 20.58* | 1.376 |
| Abduction | | | |
| Active ^t | 143.63 ± 13.77 | 120.58 ± 11.50* | 1.817 |
| Passive ^t | 160.25 ± 15.21 | 130.167 ± 13.65* | 2.082 |

Variables marked with * have significant differences between groups.

v^t are used for variables compared with Student's T test, and v^u for variables compared with Mann-Whitney's U test.

Significant differences in anthropometric variables were observed in height, arm span and relative leg length (Table 1). Foot reaction speed ability was significantly different between medallist and non-medallist athletes; differences in hand reaction time were only observed in non-dominant hand test performance, although the mean value is clearly lower (Table 1). Hip ROM was significantly different between medallists and non-medallists in both the passive flexion test with both legs and the abduction test in active and passive modality with both legs (Table 1). No difference was observed between medallists and non-medallists in jump variable (CMJ), body fat (Σ skinfolds) and active hip flexion (Active Straight Leg Raise) (Table 1).

DISCUSSION

The main aim of the present study was to compare data in variables of anthropometry, leg power, flexibility and reaction time in TKD cadet athletes, in order to observe if there are differences between values for athletes of different levels of competition success, and to check if these variables are determinant

for competitive success in this age group. To our knowledge, this is the first study evaluating physical variables in cadet athletes.

Considering that TKD is a sport in which kicking techniques constitute the predominant means of attack, anthropometric characteristics can play an outstanding role in an athlete's distance range for kicking. Significant differences between medallist and non-medallist cadet athletes have been found in anthropometry variables but results in height and arm span are contradictory to the idea reported by other authors (Kazemi et al., 2006; Markovic et al., 2005), showing lower values for this variable in medallist athletes than non-medallist (Table 1). These data agree with data reported by Cular et al. (2011) for senior athletes, and may be explained for individuality of development factors at this pubertal age, in which many corporal changes (like growing height) happen to the athlete, who requires time to adapt to the new structure (Ruiz-Fernandez, 2006). That may suggest that athletes who have not experienced these height changes are more adapted to their body proportions and so more efficient in competition, compensating for their lower height with another ability, such as greater speed and agility (Cular et al., 2011). On the other hand, the small sample in the present study may be the reason for these contradictory results.

Significant differences have been found too in relative leg length, showing higher values for medallists than for non-medallists, but no meaningful differences were observed in absolute leg length. These data may suggest that a prototype athlete with long legs in relation to the whole body might be at an advantage, in agreement with the fact that longer legs provide a longer distance for kicking the opponent, and a stronger lever for this kick (Bridge et al., 2014; Kazemi et al., 2006; Markovic et al., 2005).

Significant differences were obtained for the reaction time variable, which show that medallist athletes react faster to visual stimulus than their non-medallist counterparts. These were in agreement with previous studies in senior TKD categories and in other combat sports (Coskun et al., 2014; Fontani et al., 2006). The possible predictor character of this variable can be explained because a lower reaction time provides a faster response to opponent actions, thus the ability to block or displace easily for avoiding the scoring. In offensive actions, the reaction time is also a determinant, as the faster the execution of a technique is, the more difficult it is for the opponent to perform a blocking action and the more likely the athlete is to achieve scoring. Reaction speed improves with practice (Coskun et al., 2014), so these data may show a reciprocal relationship between reaction time and competitive success: a lower reaction time can help athletes to execute their actions more successfully, thus scoring more and winning more matches than their slower counterparts. On the other hand, if they won matches, they would pass to the next rounds and their time of practice would be greater, so they would have more time to improve their reaction ability than those athletes who lost in the first matches. Research in this area demonstrated that reaction time has a great variability regarding age and individual biological maturation (Coskun et al., 2014). This indicates that more studies in earlier categories are needed because data from senior athletes have too little agreement with cadet athlete values.

Comparing eye-hand and eye-foot reaction time, our data are in agreement with the investigation performed by Pfister et al. (2014) with non-athletes, showing that eye-hand reaction time is significantly lower than eye-foot reaction time.

Measurement of hip ROM has been performed in many previous studies with junior and senior athletes and has been described as a determinant ability for TKD athletes, in order to be able to perform kick techniques with the best path and amplitude (Bridge et al., 2014; Sadowski et al., 2012; Suzana & Pieter, 2009). Using the *Sit and Reach* test to evaluate hip ROM in many of these studies hinders proving the real, unique participation of joint ranges, as the influence of extremity length and vertebral mobility has been demonstrated (Arregui & Martínez-DeHaro, 2001). The angular test was therefore used in this study in order to measure hip joint participation only (Bridge et al., 2014; Ayala et al., 2012; López-Miñarro et al., 2012; Luque-Suárez et al., 2010). Significant differences have been found in hip ROM tests between the two groups of cadet athletes, for passive flexion variable (with both legs), and abduction variable in both active and passive modality (with both legs). Higher values shown by medallist subjects are in agreement with data from junior and senior athletes (Bridge et al., 2014; Sadowski et al., 2012; Suzana & Pieter, 2009), but do not affirm that flexibility does not appear to discriminate between athletes of different levels of competition success (Bridge et al., 2014; Kazemi et al., 2006). Furthermore, the influence of external factors to the hip joint in the *Sit and Reach* test, widely used in previous studies, may also influence the results. More studies using angular ROM test are needed so data between ages can be compared, and thus determine if this ability is a differential factor between medallists and non-medallists in all age categories.

Active hip flexion does not present significant differences between the two groups, but values are slightly higher in medallist athletes than in non-medallist. This lack of significant difference might be explained by factors like a small sample or different biological maturation changes between athletes, who tend to present much individual variability at this age, and so dispersed values. Other studies with senior athletes suggest that this non-significant difference may be explained as it is a variable considered basic for a TKD competitor in order to perform kicking techniques (Bridge et al., 2014; Casolino et al., 2012). Also, the ballistic nature of kicks in a real competition situation differs from the simple active character of the ROM test used in this study, showing that an active leg raise without a ballistic component may not correspond with real performance characteristics. The impossibility of measuring ballistic flexibility is a limitation of the present study, based on the fact that it is the closest form of flexibility to real competitive actions.

The leg power variable did not show a significant difference between the two groups. Despite this lack of significant difference, athlete values are slightly higher in medallist athletes than in non-medallist, and the effect size is considered moderate-high (Chiodo et al., 2011), so maybe limitation factors like a small sample or different biological maturation states between athletes could have shortened these differences. As with active hip flexion, some previous studies (Casolino et al., 2012) report that leg power is considered a basic

variable for a TKD competitor in order to perform kicks up to point threshold for scoring in each category with the official electronic scoring system (WTF, 2016; Casolino et al., 2012). This assumption about leg power as basic ability could explain that this variable cannot discriminate between athletes of different levels of competition success. In addition, there is evidence for higher CMJ performances in senior TKD athletes compared with junior ones (Bridge et al., 2014), that may reflect the remarkable variation in muscle fibre composition and motor unit activation according to different age population (Komi & Karlsson, 1978). This continuous development along the age transition may be the reason for these poor results for this variable in cadet athletes, who have insufficiently mature muscular characteristics to make the difference.

According to measurements performed in the present study, anthropometric variables (height, arm span and relative leg length), foot reaction time, hand reaction time of the non-dominant hand, passive hip ROM in flexion and active and passive abduction of both legs were significant differentiator factors according to TKD competition performance in the cadet category.

CONCLUSIONS

This study aims to provide some first data that could guide future investigations around cadet TKD athletes and their competition characteristics, because of the fact that this category is the first age category internationally recognised for official competition in TKD, and very few references have been found to cadet fighters as compared with older fighters. The results obtained in the present study show that there are significant differences in values for medallist and non-medallist athletes for anthropometric variables (height, arm span and relative leg length), foot reaction time, hand reaction time of the non-dominant hand, passive hip ROM in flexion, and active and passive abduction of both legs. The findings of the present investigation thus suggest that variables such as anthropometry, reaction speed ability and hip ROM can be used in talent detection programmes to select athletes with a higher predisposition to success. The main limitation of the present study is the difficulty of finding a large enough sample with the specific characteristics for this kind of study (age, competitive experience): we are therefore cautious in the interpretation and extrapolation of these results. More research is needed for cadet athletes, including a greater number of subjects, in order to be able to obtain more generalised results for this age group. Some factors such as ballistic flexibility, which can be important for TKD competition, should be investigated in future research.

According to the results obtained, coaches should evaluate determinant characteristics in their athletes so as to provide technification training as soon as possible. Further research should attempt to replicate these findings and examine whether these variables show differences in other cadet populations, so as to allow the development of specific technification training recommendations.

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