MOTOR ABILITY PROFILE OF JUNIOR AND SENIOR MALE SOUTH AFRICAN TAEKWONDO ATHLETES

Musa Lewis Mathunjwa[1], Sam Mugandani[1], Abidemi Kappo[2], Svetoslav Ivanov[3] & Trayana Djarova-Daniels[2]

[1]Department of Biokinetics and Sports Science, University of Zululand, KwaDlangezwa, South Africa;
[2]Department of Biochemistry and Microbiology, University of Zululand, KwaDlangezwa, South Africa.
[3]Bulgarian Union of Physical Culture and Sport; Bulgarian Taekwondo and Judo federation, Bulgaria.

ABSTRACT

Introduction: The purpose of this study was to assess and compare motor abilities in young and adult male South African Taekwondo athletes. To date, knowledge of the motor ability demands of this combat sport is in its infancy. Methodology: Participants were profiled as junior (n = 25, 15.5 ± 2.6 years, 163.0 ± 13.4 cm, 53.3 ± 10.7kg) and senior (n = 20, 23.5±2.5 years, 166.8 ± 7.9cm, 68.6±7.9kg) males from a local Taekwondo (WTF) club in South Africa. Flexibility (sit-and reach), abdominal strength and endurance (60-second sit-ups and 2 minutes push ups), explosive leg power (vertical jump), agility (T-test), aerobic power (20 m bleep test) converted to maximum oxygen uptake (VO_{2max}) were measured. Data were analysed with t-test for independent samples and Z-score individual radar plot statistics for each athlete. Results: There was no significant difference in agility between juniors (10.9 ±0.4s) and seniors (12.6 ± 1.2s) ($p>0.05$). The seniors showed significant ($p<0.05$) higher values in sit ups (53.1 ± 6.1 vs 48.9 ±13.8), push-ups (76.6 ± 17.1 vs 25.6 ±10.6), sit & reach (54.6 ±5.8 vs 40.1± 7.5 repetitions), horizontal jump (2.6 ± 1.1 vs 1.9 ±0.3), and VO_{2max} (52.5 ± 2.8 vs 42.2 ±6.6) than in juniors. More extensive research is required before extending existing knowledge from this study in order to permit specialized conditioning with junior athletes leading to improved motor ability at an early stage of Taekwondo training, resulting into better combat performances. Conclusions: The results showed that the performance of senior male Taekwondo athletes is higher than the juniors'.

Key words: *Taekwondo athletes, motor ability, VO_{2max}, Kyorugi, Z-score radar plot*

INTRODUCTION

Taekwondo (TKD) was officially accepted as an Olympic combat sport at the Sydney Olympics in 2000 (Lin et al., 2006). TKD has technically advanced into one of the frequently practiced martial arts worldwide with about 70 million participants in 180 countries (Fong & Ng, 2011). TKD is a dynamic form of unarmed self-defence that incorporates a variety of techniques for the purpose of attack, and can be distinguished from other martial arts by its focus on kicking techniques that are performed at a high speed (Bridge et al., 2014; Hammami et al., 2013).

TKD is characterized by three main areas in competition: sparring (free fighting), poomsae (forms), destructions (breaking of wood and tiles) which require complex motor and functional skills, tactical excellence and a high level of fitness to excel (Cular et al., 2013; Melhim, 2001). International TKD athletes are categorised in different weight divisions for both male and female athletes to participate in poomsae and sparring. Poomsae is a structural form of group competition in which the participant simultaneously uses both hands and feet to display various techniques (Haddad et al., 2014). In Kyorugi, combat matches are typically performed in three rounds of 2 minutes with 1-minute rest period (World Taekwondo Federation, 2015). Points are awarded when kicks and punches make contact on the

allowed body area. A winner is determined by scoring more points or by a knockout.

There is an insufficient amount of scientific information on anthropometric and energy demand (Kazemi et al., 2009; Ball 2011), physiological profile (Kazemi et al., 2009), mental development skills (Chiodo et al., 2011; Pieter & Heijmans, 2000) with high technical and tactical proficiency (Bridge et al., 2011; Kazemi et al., 2009) of TKD sport. Additionally, there is lack of information regarding age and development in Taekwondo making it challenging to determine the impact of differences in physical profile between junior male and female TKD athletes (Mathunjwa et al., 2015). More so, research among Senior South African Taekwondo athletes during both International Taekwondo Federation (ITF) and World Taekwondo Federation (WTF) competitions is scarce. Therefore, the purpose of this study was to assess and compare motor abilities in both senior and junior male Taekwondo athletes.

METHODOLOGY

Participants in this study were junior (n = 25) and senior (n = 20) males from a local Taekwondo (WTF) club in South Africa who freely volunteered to participate in this study. Following an explanation of all procedures, risks and benefits, each participant expressly gave their informed consent to participate in the study. The participants were involved in Taekwondo training and were members of the South African Taekwondo Federation. Ethical clearance for the study was obtained from the University of Zululand. Data were analysed using *t*-test for independent samples and Z-score individual radar plots statistics for each athlete.

Procedure

The following tests were administered: measurements such as flexibility (sit-and-reach test), abdominal strength and endurance (60-second sit-ups and 2-minute push ups test), explosive leg power (vertical jump test), agility (*t*-test), aerobic power (20 m bleep test) converted to maximum oxygen uptake (VO_{2max}).

Anthropometric measurements

Body mass of the individuals was measured in kilogram (kg) using a digital scale (Kubota KA – 10 – 150V, Japan). Stature was measured using a stadiometer (La Fayette Instrument Co. USA) and body mass index was calculated as weight divided by height squared (kg/m^2) (Ross & Marfell-Jones, 1991).

Physical tests and physiological performance measurements

The details of these measurements were presented in a previous paper (Mathunjwa et al., 2015). Flexibility (cm) was measured in centimetres by the modified sit-and-reach test using the Lafayette sit and reach box (Model 01285A, La Fayette, USA). The T-test (sec) was used to determine the agility of body trunk without loss of balance including forward, lateral and backward running (Raven et al., 1976; Getchell, 1985). Leg power was measured by standing broad jump (cm) (Johnson & Nelson, 1986). A tape measure was used (Stanley Power Locks, Tokyo, Japan) to measure the distance after jumping forward on a floor surface. The 20 min multi stage fitness test (MSFT) was used to measure endurance capacity. This test measured continuous running between two lines 20 meters apart in time to recorded beeps (Gabbett et al., 2009). Muscular strength and endurance were assessed by the one-minute sit-ups and two-minute push-up test (repetitions) respectively (Sparling, 1997).

Statistical analysis

Data were analysed using mean and standard deviations. The *t*-test was computed to determine if differences exist between senior and

junior athletes. Significance was set at $p<0.05$. Due to the relatively small sample size, the statistical power of the study was calculated using two statistical power calculators: Alpha error level criterion set at 0.05 or 5% confidence level and Beta criterion set at 0.80 or 80% confidence level (Zodplay, 2004). The Z-criterion statistics (Marronna et al., 2006) was applied for preparing computerized individual performance Z-score radar plots (Mathunjwa et al., 2015), which were then used for comparison.

RESULTS

The descriptive statistics of the performance variables in both senior and junior South African Taekwondo athletes are displayed in Table 1. Senior Taekwondo athletes tend to have higher body mass and stature than juniors. No significant difference was noted in BMI and sit-ups. Statistically, significantly higher difference ($p<0.001$) in push-ups, horizontal jumps, sit & reach and VO_{2max} ($p<0.05$) was found in senior athletes when compared to junior athletes.

Table 1. *Physical characteristics between South African Senior vs Junior Taekwondo athletes (mean±SD).*

Parameters	(Senior (n=20	(Junior (n=25	Δ	Δ%
(Age (years	23.5±2.5	15.5±2.6	0.3	34.0
(Weight (kg	68.6±9.0	53.8±10.7	0.2	21.6
(Height (cm	*7.9 ± 166.8	13.4 ± 163.0	0.2	2.3
(BMI (kg/m^2	22.9±2.3	20.9±1.3	0.1	8.7
(Sit & Reach (cm	*54.2±5.8	40.1±7.9	0.3	26.0
Sit ups 60 s	53.1±6.1	48.9±13.8	0.1	7.9
Push-ups 2mins	**76.8±17.4	25.6±10.5	0.6	66.7
(Horizontal Jump (m	*2.3±0.3	1.2±0.1	0.5	47.8
(VO_{2max} (ml/kg/min	*52.5±2.8	42.2±6.8	0.2	19.6

**p<0.001, *p<0.05, Δ: change, % percentage, cm: centimeters, kg: kilograms

Z-criterion statistics was used to design Z-score radar plots based on the following physical characteristics (Sit-and- reach, sit-ups, push-ups, horizontal jump, T-test, aerobic power) that are key performance indices in Taekwondo. The results of individual Z-score radar plots (in %) of a senior TKD athlete approximately the same weight category with a junior TKD athlete is presented in Table 2 and figure 1 and 2.

Table: 2. *Individual Z-score (in %) of senior and junior TKD athletes*

Z-score	Sit & Reach (cm)	Sit ups 60 s	Push-ups 2mins	Horizontal Jump (m)	VO_{2max} (ml/kg/min)
NM Senior	51	49	68	2.2	52.1
MZ Junior	42	47	28	1.1	42

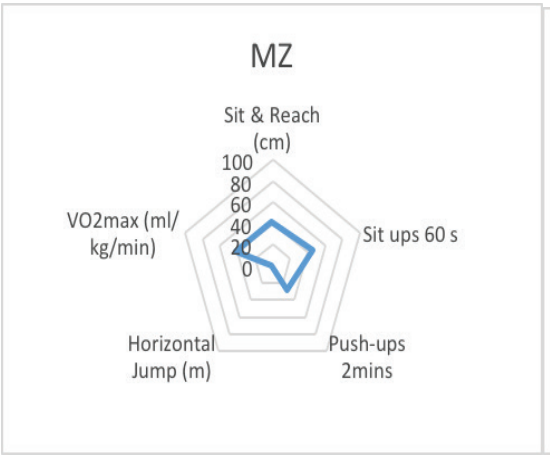

Figure 1: *Z-score individual radar plots (in %) of senior athlete NM*

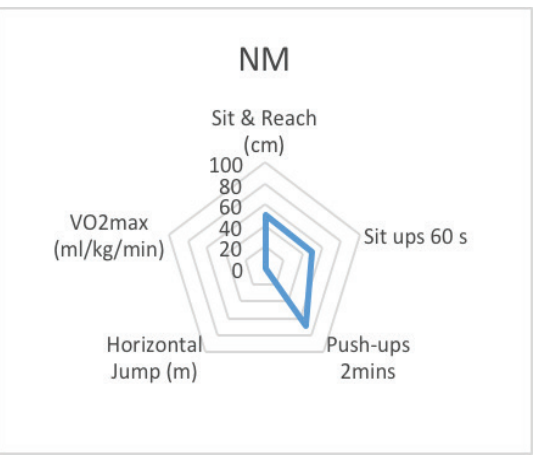

Figure 2: *Z-score individual radar plots (in %) of junior athlete MZ*

Analysis of individual Z-score

Athlete NM (Figure 1) displayed a higher level of push ups and good flexibility. His kicking execution will be strong when attacking an opponent. Due to high flexibility, the athlete will be able to reach the targeted area during a fight. Athlete MZ, being a junior, has an advantage due to his better $VO_{2max.}$ He, therefore, needs to avoid effective kicks from an opponent by always counter attacking, so that he can endure longer during fights since his muscular endurance is poor.

DISCUSSION

This study has been able to support the fact that enhanced motor abilities play an important role in improving combat performance, and contributing to short and long term health of athletes. This is in consonance with the study of Ortega and colleagues (2008). The five main components of motor ability (flexibility, endurance, strength, power and cardiorespiratory fitness) (Ruiz et al., 2006) were assessed in senior and junior TKD athletes. Stature, weight and body mass index (BMI) were also measured at the same time points.

TKD athletes regularly reduce their body mass to compete in selected weight categories and to optimize their power during combat (Tsai et al., 2011). The body mass recorded in this study correlates with data values reported in previous studies and have been recommended to facilitate performance and maintain good health (Bridge et al., 2014; Rodriguez et al., 2009).

The study also confirms that flexibility plays an important role in TKD and gives athletes an advantage in performing high kicks. As reported by Chan and colleagues (2001), TKD training is known to enhance flexibil-

ity due to multiple bouts of static and ballistic stretching that increases during physical fitness. It was noted in this study that junior TKD athletes produced lower sit and reach than seniors (see Table 1). Kim et al. (2011) established that training adaptation and the technical demands of sport produces higher flexibility. This, therefore, explains the reason why senior athletes display higher flexibility scores than the juniors (Bridge et al., 2014).

A study reported that VO_{2max} scores of junior male TKD athletes ranges between 41-49 ml/kg/min (Bridge et al., 2011). This shows that the cardiorespiratory fitness of the athletes in our study is comparable with other international athletes (see Table 1). Although, the value of the senior athletes was higher than that of the junior athletes nonetheless, it was noteworthy to show that the present results from this study meet international standards.

TKD athletes require submaximal muscular endurance and strength to sustain repeated combat movement in competitons (Moir, 2012). The data obtained from sit-ups and push-ups in both senior and junior athletes gave an insight of muscular endurance and strength (see Table 1). Even though there are limited studies that have examined push-ups and sit-ups of international TKD athletes (Toskovic et al., 2004; Markovic et al., 2005), the results from these studies was in agreement with the data from our study.

The Z-score radar plots based on the five most relevant motor abilities (flexibility, endurance, strength, power and VO_{2max}) were measured to assess the individual performance of the TKD athletes. In conclusion, the individual Z-score analysis implemented in the current study was used to analyse and interpret the result of individual performances of TKD athletes in order to provide coaches with specific information relevant for the design of unique training regimen for each athlete.

REFERENCES

Ball, N., Nolan, E. and Wheelere K. (2011), Anthropometrical, physiological, and tracked power profiles of elite taekwondo athletes 9 weeks before the Olympic competition phase. *Journal of Strength Conditioning and Resistance, 25,* 2752–2763.

Bridge, C.A., D.A Silva Santos, J.F., Chaabene, H., Pieter, W. and Franchini, E. (2014), Physical and physiological profiles of taekwondo athletes. *Sports Medicine,* 44(6): 713-733.

Bridge, C.A., Jones., M.A. and Drust, B. (2011), The activity profile in international taekwondo competition is modulated by weight category. *International Journal of Sports Physiology and Performance*, 6(3): 344-357.

Chan, S. P., Hong, Y., & Robinson, P. D. (2001), Flexibility and passive resistance of the hamstrings of young adults using two different static stretching protocols. *Scandinavian Journal of Medicine and Science in Sports,* 11, 81–86.

Chiodo, S., Tessitore A., Cortis C., Cibelli G., Lupo C., Ammendolia A., De Rosas M. And Capranica, L. (2011), Stress-related hormonal and psychological changes to official youth taekwondo competitions. *Scandinavian Journal Medical Science Sports*, 21:111–119.

Chiodo, S., Tessitore, A., Lupo, C., Ammendolia, A., Cortis, C. & Capranica, L. (2012), Effects of official youth taekwondo competitions on jump and strength performance. *European Journal of Sport Science*, 12(2), 113-120.

Cular, D., Munivrana, G. and Katić, R. (2013), Anthropological analysis of taekwondo new methodological approach, *Collegium Antropologicum,* 37(3): 901–906.

Fong, S.S.M. and Ng, G.Y.F. (2011), Does taekwondo training improve physical fitness? *Physical Therapy in Sport,* 12(2): 100–106.

Gabbett, T., Kelly, J., Ralph, S. and Driscoll, D. (2009), Physiological and anthro-

pometric characteristics of junior elite and sub-elite rugby league players, with special reference to starters and non-starters. *Journal of Science Medicine and Sport,* 12(1):215-222.

Haddad, M., Chaouachi, A., Wong Del, P., Castagna, C., Hue, O., Impellizzeri, F.M. & Chamari, K. (2014), Influence of exercise intensity and during on perceived exertion in adolescent, Taekwondo athletes. *European Journal of Sport Science,* 14(1): 275-281._

Hammami, N., Zinoubi, B., Hamdi, F., Nouri, A., Zouita, A. & Dziri C. (2013). Isokinetic profile of knee muscles in olympic elite taekwondo practitioners. *Science Sports,* 28: 188–195.

Johnson, B.I. and Nelson, J.K. (1986), Practical measurements for evaluation in physical education. New York: Macmillan Publishing Company.

Kazemi, M., Casella, C. and Perri, G. (2009). 2004. Olympic taekwondo athlete profile. *Journal of the Canadian Chiropractic Association,* 53(2), 144–152.

Kim, H., Stebbins, C.L., Chai, J. and Song, J. (2011), Taekwondo training and fitness in female adolescents. *Journal of Sports Sciences*, 29(2), 133-138.

Leger, L.A., Mercier, D., Gadoury, C. and Lambert, J. (1988), The Multistage 20M shuttle run test for aerobic fitness. *Journal of Sports Sciences*, 6(2): 93-101.

Lin, W.L., Yen K.T., Lu, C.Y.D., Huang, Y.H. and Chang, C.K. (2006), Anaerobic capacity of elite taiwanese taekwondo athletes. *Science and Sports,* 21 (5), 291-293.

Markovic, G., Misigo-Durakovic, M. and Trninic S. (2005). Fitness profile of elite Croatian female taekwondo athletes. *Collegium Anthropologicum*, 29(1), 93–99.

Marronna, R. A., Martony, R.D. and Yohar, V.J. (2006), *Robust Statistics*: Theory and Methods: Wiley, New York.

Mathunjwa, M.L., Mugandani, S.C., Ngcobo, M., Djarova-Daniels, T. and Ivanov, S. (2015). Physical, anthropometrical, and physiological profiles of experienced junior male and female South African Taekwondo athletes. *African Journal for Physical, Health Education, Recreation and Dance,* 21(4:2), 1402-1416.

Moir, G. (2012). Muscular endurance. In T. Miller (Ed.), *National Strength and Conditioning Association: NSCA's Guide to Tests and Assessments* (pp. 193–217), Champaign, IL: Human Kinetics.

Ortega, F. B., Ruiz, J. B., Castillo, M. J., & Sjostrom, M. (2008). Physical fitness in childhood and adolescence: A powerful marker of health. *International Journal of Obesity,* 32, 1–11.

Pieter, W. and Heijmans J. (2000). Scientific Coaching for Olympic Taekwondo. 2nd ed. Oxford, UK: Meyer & Meyer Sport.

Raven, B.P., Gettman, L.R., Pollock, M.L. and Cooper, K.H. (1976). A physiological evaluation of professional soccer players. *British Journal of Sports Medicine,* 10(4): 209-216.

Rodriguez, N.R., DiMarco, N.M. and Langley, S. (2009). Position of the American Dietetic Association, Dietitians of Canada, and the American College of Sports Medicine: Nutrition and athletic performance. *Journal of American Diet Association*, 109(3), 509–527.

Ruiz, J. R., Ortega, F. B., Gutierrez, A., Meusel, D., Sjo¨ Stro¨m, M. and Castillo, M. J. (2006). Health-related fitness assessment in childhood and adolescence: A European approach based on the AVEN, EYHA and HELENA studies, *Journal of Public Health*, 14, 269–277.

Sparling, P.B. (1997). Field testing for abdominal muscular fitness. ACSM's *Health Fitness Journal*, 1(4), 30-33.

Toskovic, N.N., Blessing, D. & Williford. H.N. (2004). Physiologic profile of recreational male and female novice and experienced Tae Kwon Do practitioners. *Journal of Sports Medicine and Physical Fitness*, 44(2), 164–172.

Tsai, M.L., Chou, K.M., Chang, C.K. & Fang, S.H. (2011). Changes of mucosal immunity and antioxidation activity in elite male Taiwanese taekwondo athletes associated with intensive training and rapid weight loss. *British Journal of Sports Medicine*, 45(9), 729–734.

World Taekwondo Federation [Internet]. World Taekwondo Federation Competition Rules & Interpretation. [updated 2015] Sep; cited 2015 Dec 3]. Available from http://www.worldtaekwondofederation.net/images/Final_CompetitioRules Amendmen_t _E Voting_2015_copy_copy pdf, 17.

Zodpla Y, S.P. (2004). Sample size and power analysis in medical research. *Indian Journal of Dermatology, Venereology and Leprology,* 70 (2), 123-128.

Correspondence:

Musa Lewis Mathunjwa
University of Zululand, Human Movement Science Department
KwaDlangezwa 3886, Durban, KwaZulu Natal 3886
South Africa
E-mail: mlmathunjwa@gmail.com