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PHYSICAL FITNESS OF RECREATIONAL ADOLESCENT TAEKWONDO ATHLETES

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ABSTRACT

NOORUL, H. R. ; PIETER, W.; ERIE, Z. Z. Physical Fitness of Recreational Adolescent Taekwondo Athletes. Brazilian Journal of Biomotricity, v. 2, n. 4, p. 230-240, 2008. The purpose of this study was to describe the physical fitness of adolescent recreational taekwondo athletes. Subjects were members of the Kelantan State taekwondo team from Malaysia (8 males, 18.63 ± 1.92 years, 168.65 ± 7.36 cm, 68.29 ± 20.69 kg, and 9 females, 18.10 ± 1.37 years, 158.22 ± 4.11 cm, 59.72 ± 10.03 kg). Flexibility, explosive leg power, muscular strength and endurance, aerobic fitness and maximum exercise heart rate (HRex) were assessed. In absolute terms, the boys (52.07 ± 11.07cm) jumped higher than the girls (34.04 ± 5.21 cm, $p = 0.001$, $eta^2 = 0.476$). The difference became smaller when jump height was scaled to height (m^2) (17.39 ± 3.07 cm/m2 and 14.25 ± 1.66 cm/m^2 for the boys and girls, respectively, $p = 0.020$, $eta^2 = 0.331$). There was no difference between boys (25.00 ± IR15) and girls (31.50 ± IR 17) in push-ups, although the females recorded a higher median score ($p = 0.335$, ES = 0.406). There also was no difference between gender (39.00 ± IR7 vs. 39.50 ± IR11) in sit-ups ($p > 0.05$, ES = 0.054). The boys had greater aerobic endurance but the effect was small (42.18 ± 7.86 $ml.kg^{-1}.min^{-1}$ vs. 30.71 ±5.46 $ml.kg^{-1}.min^{-1}$, $p = 0.003$, $eta^2 = 0.453$). The difference persisted when height was used as a co-variate (43.32 ± 8.44 $ml.kg^{-1}.min^{-1}$ for the boys and 29.70 ± 8.283 $ml.kg^{-1}.min^{-1}$ for the girls, $p = 0.012$, $eta^2 = 0.375$). In conclusion, sexual

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dimorphism in physical fitness was found in recreationally active adolescent athletes.

Keywords: Taekwondo, Malaysian, fitness, adolescent

INTRODUCTION

Most studies on taekwondo have been conducted on adults. For instance, Taaffe & Pieter (1990) reported sexual dimorphism in elite American taekwondo athletes (*taekwondo-in*) in terms of aerobic and anaerobic endurance. Toskovic et al. (2002) found that dynamic taekwondo performance resulted in heart rate responses (88.3 – 92.2% of maximal heart rate) that were above the 60% threshold recommended for a cardiovascular training effect (FRANKLIN et al., 2000).

A relationship between experience and physical fitness was revealed by Toskovic et al. (2004), while Heller et al. (1998) demonstrated that experienced *taekwondo-in* had low body fat as well as higher aerobic endurance and flexibility than less experienced colleagues. Others confirmed that elite *taekwondo-in* may be characterized by low fat and well-developed aerobic endurance (BOUHLEL et al., 2006).

Markovic et al. (2005) found higher explosive leg power, aerobic endurance and flexibility in successful female Croatian elite *taekwondo-in*. Elite Czech male and female *taekwondo-in* recorded 36.9 cm and 37.9 cm, respectively, on the sit-and-reach test, which was 158% and 142% of the Czech norm population. Vertical jump measured on a Kistler force platform was 45.4 cm for males and 29.8 cm for females, which corresponded to 119% and 109%, respectively, of the population scores (HELLER et al., 1998). American recreational *taekwondo-in* showed that there was no experience effect in terms of explosive leg power but there was for taekwondo-specific flexibility, i.e., lateral splits, with the more experienced practitioners performing better (TOSKOVIC et al., 2004).

Few studies are available on young taekwondo participants and most were done in the West (e.g., PIETER, 1991). Cetin et al. (2005) developed a regression equation to determine aerobic endurance in 16-year old Turkish boy and girl taekwondo athletes.

Research on taekwondo in Malaysia was only recently started by the second author (WP). For instance, Suzana & Pieter (2006) reported young national taekwondo athletes to improve in motor abilities after an intervention. Collapsed over gender, sit-and-reach flexibility improved over time. The boys had greater absolute explosive leg power than the girls, even after allometric scaling for body mass with an empirically derived exponent.

Erie et al. (2007) found boys to have greater aerobic endurance (49.03 $ml.kg^{-1}.min^{-1}$) than girls (39.54 $ml.kg^{-1}.min^{-1}$) even after controlling for height (48.40 $ml.kg^{-1}.min^{-1}$ versus 40.17 $ml.kg^{-1}.min^{-1}$). The purpose of this study, then, was to assess and compare the physical fitness of Malaysian adolescent recreationally competitive *taekwondo-in*.

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METHODS

Subjects

Participants (9 girls and 8 boys) were members of the Kelantan taekwondo team in Malaysia preparing itself for an upcoming national tournament. Table 1 shows the means and standard deviations of the athletes' demographic data. Ethical approval was obtained from the University of Asia and the Pacific and informed consent signed by the subjects or their coach.

Table 1: Descriptive statistics of demographic data of adolescent *taekwondo-in*

	Males	Females
Age (years)	18.63 ± 1.92	18.10 ± 1.37
Height (cm)	168.65 ± 7.36	158.22 ± 4.11
Weight (kg)	68.29 ± 20.69	59.72 ± 10.03
Percent fat	21.40 ± 6.30	32.46 ± 3.93
Lean body mass (kg)	52.57 ± 11.18	40.00 ± 4.52

Procedures

Height was measured by means of a wall-mounted stadiometer (Lafayette Instrument Co. USA, Lafayette, IN, USA) and body mass on a calibrated digital scale (SECA, Vogel & Halke, GmbH & Co, Hamburg, Germany). Body composition included percent fat calculated according to the formula of Deurenberg-Yap et al. (2000) and lean body mass (LBM) derived.

Flexibility was assessed using the modified sit-and-reach test (MORROW et al., 2005). The counter-movement vertical jump (CMJ) was used to assess explosive power of the legs. However, no attempt was made to control for the angle of the knees when lowering the body before the jump, as suggested by Domire & Challis (2007). The subjects were allowed three jumps with a 1-minute rest in between them. The highest jump was used for statistical analysis.

Aerobic fitness was estimated by means of the 20 m multi-stage fitness test (MSFT) (RAMSBOTTOM et al., 1988). The test was terminated when the participants could no longer keep up with the set pace and failed to reach the turning line on two consecutive occasions (e.g., KILDING et al., 2006). Maximum exercise heart rate (HRex) was measured using a Polar watch (Polar Electro Oy, Kempele, Finland).

Statistical Analysis

Data distributional characteristics were verified with the Kolmogorov-Smirnov test, while coefficients for skewness and kurtosis were also calculated. Log transforms were used for non-normal data. A 1-way ANOVA was employed to determine the differences in physical fitness between boys and girls. The median test was utilized to assess the differences between gender in push-ups and sit-ups. To partition out the independent influence of height on aerobic endurance it was entered as a co-variate (WELSMAN et al., 1996). Allometric scaling was employed to compare boys and girls in explosive power relative to

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height (m^2) and LBM ($kg^{0.67}$) (ASTRAND et al., 2003; MARKOVIC & JARIC, 2007). Pearson correlations were calculated to assess to what extent allometric scaling, using the theoretical exponents, controlled for the effect of the body size variable.

No adjustment for the familywise type 1 error was made for multiple comparisons (FEISE, 2002). The objective was to unearth any possible leads regarding the relationship between the independent and dependent variables (BENDER and LANGE, 2001; ROTHMAN, 1990). The estimated power for the sample size used was 80%.

RESULTS

There was no difference in age between the male and female *taekwondo-in* ($p = 0.508$, $eta^2 = 0.028$). There was a small difference in height ($p = 0.002$, $eta^2 = 0.476$), but no difference in weight ($p = 0.264$, $eta^2 = 0.077$).

The girls had a higher relative percent total body fat ($p < 0.001$) but the effect was moderate ($eta^2 = 0.566$). The boys had more lean body mass ($p = 0.005$) but this difference was small ($eta^2 = 0.399$).

Table 2 displays the means and standard deviations of flexibility (cm) and vertical jump (cm). There was no difference between boys and girls in right leg flexibility ($p = 0.355$, $eta^2 = 0.054$) and neither was there a difference for the left leg ($p = 0.142$, $eta^2 = 0.130$).

Table 2: Descriptive statistics of flexibility (cm) and explosive power (cm) of adolescent *taekwondo-in*

	Males	Females
Flexibility (R)	34.43 ± 5.38	36.79 ± 5.11
Flexibility (L)	31.99 ± 6.17	35.75 ± 4.15
Vertical jump	52.07 ± 11.07	34.04 ± 5.21

The boys jumped higher than the girls ($p = 0.001$) but the effect was small ($eta^2 = 0.476$). The difference became smaller when scaled for height (m^2): 17.39 ± 3.07 cm for boys and 14.25 ± 1.66 cm for girls ($p = 0.020$, $eta^2 = 0.331$). The theoretical exponent for height controlled for the effect of the body size variable relative to the vertical jump in the boys ($r = -0.08$, $p = 0.864$) but not in the girls ($r = -0.71$, $p = 0.033$).

When the vertical jump was expressed in terms of LBM ($kg^{0.67}$), the difference between boys and girls disappeared ($p = 0.179$, $eta^2 = 0.125$): 3.52 ± 0.88 cm versus 3.06 ± 0.41 cm. The theoretical exponent for lean mass controlled for the effect of the body size variable relative to the vertical jump in the boys ($r =-0.66$, $p = 0.109$) but not in the girls ($r = -0.83$, $p = 0.006$).

There was no difference between boys and girls in push-ups (see Table 3), although the females recorded a higher median score (p = 0.335. ES = 0.406). There also was no difference between gender in sit-ups ($p > 0.05$, ES = 0.054).

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Table 3: Descriptive statistics (median ± inter-quartile range) of muscular strength and endurance in adolescent *taekwondo-in*

	Males	Females
Push-ups (reps)	25.00 ± 15	31.50 ± 17
Sit-ups (reps)	39.00 ± 7	39.50 ± 11

Table 4 depicts the means and standard deviations of aerobic endurance and exercise heart rate. The boys had a higher aerobic endurance ($p = 0.003$, $eta^2 = 0.453$). After using height as a co-variate, the boys (43.32 ± 8.44 $ml.kg^{-1}.min^{-1}$ vs. 29.70 ± 8.28 $ml.kg^{-1}.min^{-1}$) still had a higher aerobic endurance ($p = 0.012$), although the difference was still small ($eta^2 = 0.375$). The boys had a higher exercise heart rate than the girls, but the effect was samll ($p = 0.002$, $eta^2 = 0.483$).

Table 4: Descriptive statistics of aerobic endurance and exercise heart rates in adolescent *taekwondo-in*

	Males	Females
Peak VO_2 ($ml.kg^{-1}.min^{-1}$)	42.18 ± 7.86	30.71 ± 5.46
Heart rate (bpm)	195.71 ± 6.30	182.22 ± 8.27

DISCUSSION

The difference in height and lean body mass between the recreational taekwondo boys and girls was small. Although not statistically significant, recent research seems to suggest that at the elite level these body size variables account for 60%-70% of the variance in performance of Olympic *taekwondo-in* (PIETER, 2004). Greater height facilitates reach in kicking and punching (OLDS & KANG, 2000). Significant but inconsistent relationships were reported by Pieter (1991) and Pieter & Pieter (1995) between body mass, lean body mass, momentum, force and speed in a range of kicks and punches. It is suggested that sexual dimorphism might increase with higher levels of competition, leading to gender-specific morphological optimization (PIETER, 2004).

Sexual dimorphism in body composition in martial arts athletes in general and taekwondo athletes in particular was reported before in Caucasian adult recreational, and young and adult elite *taekwondo-in* (e.g., CHAN et al., 2003; HELLER et al., 1998; PIETER, 1991; TAAFFE & PIETER, 1990) as well as in recreational adolescent Malaysians (AIWA & PIETER, 2007; ERIE et al., 2007). However, the difference in body composition at the elite level is suggested to be smaller (e.g., HELLER et al., 1998; TAAFFE & PIETER, 1990) due to morphological optimization (NORTON et al., 1996). In weight-categorized sports like taekwondo where speed of movement is essential to propel the body through space, excess body fat may be detrimental to optimal performance, even at the recreational level (OLDS & KANG, 2000; PIETER & HEIJMANS, 2000; TAAFFE & PIETER, 1990; SINNING, 1985). Lower body fat provides a better weight-to-strength ratio, which in turn enhances the power output-to-body

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weight ratio, important in accelerating the body mass as rapidly as possible (TAAFFE & PIETER, 1990).

Flexibility plays an important role in taekwondo competition to enable athletes to execute high kicks to k.o. the opponent. Toskovic et al. (2004) reported values of 31.7 cm (novice males), 39.1 cm (experienced males), 37.0 cm (novice females), and 35.9 cm (experienced females) for American recreational *taekwondo-in* using the conventional sit-and-reach test. Markovic et al. (2005) found 55.8 cm for the total group of elite Croatian female *taekwondo-in*. It is not clear why the American males, from a practical point of view, were more flexible than their female colleagues. Other investigators reported females to be more flexible (e.g., BERCADES et al., 1994), which was also the case in the present study. Erie et al. (2007) found the females to be more flexible from a practical perspective as well.

Published data on muscular strength and endurance in adolescent *taekwondo-in* are scarce. Suzana & Pieter (2006) reported improvements in both push-ups and sit-ups in adolescent taekwondo athletes after an intervention. The boys recorded more sit-ups at the pre-test (31 vs. 22 median repetitions) but there was no difference at the post-test (37 vs. 26 repetitions). There were no differences in push-ups between boys and girls (pre-test: 38 vs. 33 repetitions and post-test: 49 vs. 47 repetitions). Yiau et al. (2004) found no difference in push-ups between adolescent boys (30 repetitions) and girls (35 repetitions). However, the boys scored higher on the sit-ups (50 vs. 43 repetitions).

The abdominal muscles play an important role in core stability in many sports, including taekwondo. It is suggested to develop the musculature around the trunk as optimally as possible, i.e., the abdominal muscles for flexion, the lower back muscles for extension and the obliques for rotation (ROETERT, 2001). For instance, the trunk muscles are involved when punching from various stances in taekwondo or executing such kicks as the roundhouse or spinning hook kicks.

Comparative data for absolute explosive leg power using the CMJ in taekwondo and karate athletes are displayed in Table 5. American recreational *taekwondo-in* recorded heights of 43.7 cm (novice males), 51.5 cm (experienced males), 32.1 cm (novice females), and 31.3 cm (experienced females) (TOSKOVIC et al., 2002). Although differences in height or lean mass are not reflected in the table, it appears that Malaysian elite junior *taekwondo-in* (15 years) (SUZANA and PIETER, 2006) had higher explosive leg power than their recreational counterparts in the current study. Explosive power of the lower limbs was found to be high in elite *taekwondo-in*. It will not only facilitate jump kicks but will also contribute to more powerful standing and airborne kicks (HELLER et al., 1998; PIETER and HEIJMANS, 2000; TAAFFE and PIETER, 1990). Yiau et al. (2004) reported that winning Malaysian female *taekwondo-in* competing at the 2004 Malaysian Games jumped higher (39.1 cm) than their less successful colleagues (35.1 cm).

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Table 5 Absolute vertical jump height (cm) in taekwondo and karate athletes

	Males	Females
This study	52.1	34.0
Malaysian recreational *taekwondo-in* (ERIE et al., 2007)	35.6	26.0
Malaysian national junior *taekwondo-in* (SUZANA and PIETER, 2006)	56.1	36.1
Croatian elite *taekwondo-in* (MARKOVIC et al. (2005)	--	30.6
Belgian elite karate athletes (CLAESSENS et al., 1986)	54.8	--

Scaling for lean mass decreased the difference between boys and girls more than using height as the scaling factor. However, the theoretical exponents in this small sample did not adequately remove the effect of the body size variable on vertical jump height in the girls. In other words, allometric scaling failed to produce a dimensionless physiological performance variable for the girls (WELSMAN et al., 1996).

It was found that strength increased at a greater rate to height than predicted by geometric similarity theory (MARKOVIC & ROWLAND, 2005), while it was also suggested that athletic and sedentary humans may not be geometrically similar in strength (NEVILL et al., 2004). Future studies should investigate the effect of body size with empirically derived exponents on jump height (MARKOVIC & JARIC, 2005) as well as using segmental lean mass instead of whole body lean mass (FELTER et al., 2004; WELSMAN et al., 1996) with a larger sample size (MALINA et al., 2004).

Other considerations include the exact exponent for lean mass. For instance, it was suggested that increases in explosive power with age occur at the same rate as body mass or maybe even higher (ROWLAND, 2005). Suzana and Pieter (2006) found an empirically derived exponent of 0.314 for body mass in 15-17-year old *taekwondo-in*. In other words, power may not scale to $kg^{0.67}$ as was done in the current study. In addition, genetic factors were found to play a major role in explosive power, explaining between 48% – 95% of the variance in the vertical jump (ROWLAND, 2005). It might very well be, then, that the theoretical exponent for lean mass in the girls in the current study was not sufficiently adequate to control for the effect of the body size variable. In addition, no attempt was made to control for differences in the girls due to contrasting maturity status (MALINA et al., 2004).

By the same token, strength measures may improve at a greater rate with age than indicated by the exponent for height and may be more than 2 (ROWLAND, 2005). Although little supportive evidence exists, size-independent or qualitative factors may have been at the basis of the explosive power in the girls, such as muscle architecture, contractile properties and neurologic characteristics (ROWLAND, 2005).

Table 6 displays comparative data on aerobic endurance in taekwondo athletes from various countries, who were assessed using the 20 m MSFT. The adult

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male British club athletes had a similar aerobic fitness as American recreational taekwondo practitioners assessed on a treadmill (44.0 $ml.kg^{-1}.min^{-1}$) (THOMPSON & VINUEZA, 1991). Differences in training frequency and intensity as well as level of competition may have contributed to the variation in aerobic endurance as shown in Table 6.

Table 6 Peak aerobic endurance ($ml.kg^{-1}.min^{-1}$) in *taekwondo-in*

	Males	Females
This study	42.2	30.7
Malaysian adolescents (ERIE et al., 2007)	49.0	39.5
Malaysian Games athletes (YIAU et al., 2004)	48.8	37.9
British club athletes (CHAN and PIETER, 1999)	46.5	35.6

When the effect of height was accounted for in the current study, the difference in aerobic fitness between males and females decreased from moderate to small. Erie et al. (2007) also found a decrease in peak aerobic endurance when height was controlled but it was still moderate (48.40 $ml.kg^{-1}.min^{-1}$ and 40.17 $ml.kg^{-1}.min^{-1}$ for boys and girls respectively, $eta^2 = 0.603$). Chan & Pieter (1999) found no difference in height-adjusted aerobic fitness between male and female British adult recreational taekwondo athletes: 44.0 $ml.kg^{-1}.min^{-1}$ and 38.0 $ml.kg^{-1}.min^{-1}$ for males and females, respectively. There was a larger difference in height (14 cm, $eta^2 = 0.802$) between the British men and women as opposed to that in the Malaysians in the current study (10 cm) or in the one by Erie et al. (2007) (9 cm, $eta^2 = 0.517$). It might be that height will only have an effect on aerobic endurance in recreational athletes if it exceeds a minimal difference between groups.

CONCLUSIONS

Future studies should use a larger sample size, especially when applying allometric scaling (MALINA et al., 2004). This will avoid finding smaller or greater than expected point exponents with overlapping confidence intervals.

REFERENCES

AIWA, N.; PIETER, W. Sexual dimorphism in body composition indices in adolescent martial arts athletes. Brazilian Journal of Biomotricity, v. 1, n. 3, p. 56-64, 2007.

ASTRAND, P. O.; RODAHL, K.; DAHL, H. A.; STROMME, S. Textbook of Work Physiology. Physiological Bases of Exercise, 4th ed., Champaign, IL: Human Kinetics, 2003.

BENDER, R.; LANGE, S. Adjusting for multiple testing – when and how? J Clin Epidem, v. 54, n. 4, p. 343-349, 2001.

BERCADES, L. T.; PINLAC, V. A.; PIETER, W. Flexibility of Filipino martial sport athletes. In: Arroyo, E. (ed.), The Measure of the Filipino Athlete, Pasig City, Philippines: Center for Research and Communication, p. 21-23, 1994.

BOUHLEL, E.; JOUINI, A.; GMADA, N.; NEFZI, A.; BEN ABDALLAH, K.; TABKA, Z. Heart rate and blood lactate responses during taekwondo training and competition. Sci et Sport, v. 21, n. 5, p. 285-290, 2006.

CHAN, K.; PIETER, W. Aerobic and anaerobic endurance in recreational taekwondo athletes, II International Conference on Martial Arts, University of Salford, Salford, UK, June 24, 1999.

CHAN, K.; PIETER, W.; MOLONEY, K. Kinanthropometric profile of recreational taekwondo athletes. Biol Sport, v. 20, n. 3, p. 175-179, 2003.

CETIN, C.; KARATOSUN, H.; BAYDAR, M. L.; COSARCAN, K. A. Regression equation to predict true maximal oxygen consumption of taekwondo athletes using a field test. Saudi Med J, v. 26, n. 5, p. 848-850, 2005.

CLAESSENS, A.; BEUNEN, G.; LEFEVRE, J.; MERTENS, G.; WELLENS, R. Body structure, somatotype and motor fitness of top-class Belgian judoists and karateka. A comparative study. In: Reilly, T.; Watkins, J.; Borms, J. (eds.), Kinanthropometry III. London: E. & F. N. Spon, p. 53-57, 1986.

DEURENBERG-YAP, M.; SCHMIDT, G.; VAN STAVEREN, W. A.; DEURENBERG, P. The paradox of low body mass index and high body fat percentage among Chinese, Malays and Indians in Singapore. Int J Obes, v. 24, n. 8, p. 1011-1017, 2000.

DOMIRE, Z. J.; CHALLIS, J. H. The influence of squat depth on maximal vertical jump performance. J Sports Sci, v. 25, n. 2, p. 193-200, 2007.

ERIE, Z. Z.; AIWA, N.; PIETER, W. Profiling of physical fitness of Malaysian recreational adolescent taekwondo practitioners. Acta Kines Univ Tart, v. 12, p. 57-66, 2007.

FEISE, R. J. Do multiple outcome measures require p-value adjustment? BMC Medical Research Methodology, v. 2, p. 8, 2002. http:/w.w.w.biomedcentral.com/1471-2288/2/8.

FELTNER, M. E.; BISHOP, E. J.; PEREZ, C. M. Segmental and kinematic contributions in vertical jumps performed with and without an arm swing. RQES, v. 75, n. 3, p. 216-230, 2004.

FRANKLIN, B. A.; WHALEY, M. H.; HOWLEY, E. T. (eds.). ACSM's Guidelines for Exercise Testing and Prescription., 6th ed., Philadelphia: Lippincott Williams & Wilkins, 2000.

HELLER, J.; PERIČ, T.; DLOUHÁ, R.; KOHLÍKOVÁ, E.; MELICHNA, J.; NOVÁKOVÁ, H. Physiological profiles of male and female taekwondo (ITF) black belts. J Sports Sci, v. 16, n. 3, p. 243-249, 1998.

KILDING, A. E.; AZIZ, A. E.; THE, K. C. Measuring and predicting maximal aerobic power in international-level intermittent sport athletes. J Sports Med Phys Fit, v. 46, n. 3, p. 366-372, 2006.

ISSN 1981-6324

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MALINA, R. M.; BOUCHARD, C.; BAR-OR, O. Growth, Maturation, and Physical Activity, 2nd ed., Champaign, IL: Human Kinetics, 2004.

MARKOVIC, G.; JARIC, S. Is vertical jump height a body-size independent measure of muscle power? J Sports Sci, v. 25, n. 12, p. 1355-1363, 2007.

MARKOVIĆ, G.; MIŠIGOJ-DURAKOVIĆ, M.; TRNINIŠ, S. Fitness profile of elite Croatian female taekwondo athletes. Coll Antropol, v. 29, n. 1, p. 93-99, 2005.

NEVILL, A. M.; STEWART, A. D.; OLDS, T.; HOLDER, R. Are adult physiques geometrically similar? The dangers of allometric scaling using body mass power laws. Am J Phys Anthropol, v. 124, n. 2, p. 177-182, 2004.

NORTON, K.; OLDS, T.; OLIVE, S.; GRAIG, N. Anthropometry and sports performance. In: Norton, K.; Olds, T. (eds.), Anthropometrica, Sydney: UNSW Press, p. 287-364, 1996.

OLDS, T.; KANG, S. J. Anthropometric characteristics of adult male Korean taekwondo players. The 1st Olympic Taekwondo Scientific Congress Proceedings, Seoul, Korea, p. 69-75, 2000.

PIETER, F.; PIETER, W. Speed and force of selected taekwondo techniques. Biol Sport, v. 12, n. 4, p. 257-266, 1995.

PIETER, W. Age, body size and taekwondo performance at the 2004 Olympic Games: implications for talent detection, 1st Regional Conference on Human Performance, Kuala Lumpur, Malaysia, November 30-December 2, 2004.

PIETER, W. Performance characteristics of elite taekwondo athletes. Kor J Sport Sci, v. 3, p. 94-117, 1991.

PIETER, W.; HEIJMANS, J. Scientific Coaching for Olympic Taekwondo, 2nd ed., Aachen: Meyer and Meyer Verlag, 2000.

RAMSBOTTOM, R.; BREWER, J.; WILLIAMS, C. A progressive shuttle run test to estimate maximal oxygen uptake. Brit J Sports Med, v. 22, n. 4, p. 141-144, 1988.

ROETERT, E. P. 3-D balance and core stability, In: Foran, B. (ed.), High-Performance Sports Conditioning, Champaign, IL: Human Kinetics, p. 119-137, 2001.

ROTHMAN, K. J. No adjustments are needed for multiple comparisons. Epidem, v. 1, n. 1, p. 43-46, 1990.

ROWLAND, T. Children's Exercise Physiology, 2nd ed., Champaign, IL: Human Kinetics, 2005.

SINNING, W. E. Body composition and athletic performance. In: CLARKE, D. H.; ECKERT, H. M. (eds.), Limits of Human Performance. The Academy Papers #18. Champaign, IL: Human Kinetics Publishers, p. 45-56, 1985.

SUZANA, M. A.; PIETER, W. The effect of training on general motor abilities in young Malaysian taekwondo athletes. Acta Kines Univ Tartuensis, v. 11, p. 87-96, 2006.

TAAFFE, D.; PIETER, W. Physical and physiological characteristic of elite

ISSN 1981-6324

taekwondo athletes, In: Commonwealth and international Conference Proceedings. v. 3. Sport Science Part 1, Auckland, New Zealand: NZAHPER, p. 80-88, 1990.

THOMPSON, W. R.; VINUEZA, C. Physiologic profile of tae kwon do black belts. Sports Med Train Rehab, v. 3 n. 1, p. 49-53, 1991.

TOSKOVIC, N. N.; BLESSING, D.; WILLIFORD, H. N. Physiologic profile of recreational male and female novice and experienced tae kwon do practitioners. J Sports Med Phys Fit, v. 44, n. 2, p. 164-172, 2004.

TOSKOVIC, N. N.; BLESSING, D.; WILLIFORD, H. N. The effect of experience and gender on cardiovascular and metabolic responses with dynamic tae kwon do exercise. J Strength Cond Res, v. 16, n. 2, p. 278-285, 2002.

WELSMAN, J.; ARMSTRONG, N.; NEVILL, A.; WINTER, E.; KIRBY, B. Scaling peak VO2 for differences in body size. Med Sci Sport Ex, v. 28, n. 2 p. 259-265, 1996.

YIAU, L.; THUNG, J. S.; PIETER, W. General physical fitness in young *taekwondo-in* at the 2004 Malaysian Games, 1st Regional Conference on Human Performance, Kuala Lumpur, Malaysia, November 30-December 2, 2004.

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ISSN 1981-6324