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Skinfold Patterning in Elite Spanish and American Junior *Taekwondo-in*

Submission: 5.06.2010, acceptance: 12.10.2010

Key words: Fat distribution, combat sports, young

Abstract:

Purpose: Gender is suggested to be the most important determinant of fat patterning, while the effect of sport should also be taken into account [Malina *et al.* 1982]. Although fat patterning in combat sports has been investigated before [Pieter *et al.* 2006], there is no information on it in taekwondo. Therefore, the purpose of this study was to compare the skinfold patterning of international elite junior Spanish and American *taekwondo-in*.

Methods: Subjects were members of the junior national teams of Spain (10 boys, 16.70±1.49 years, 173.30±9.68 cm, 61.88±13.24 kg; 11 girls, 16.64±1.50 years, 162.16±6.69 cm, 54.96±10.60 kg) and the United States (9 boys, 15.44±1.21 years, 165.94±12.82 cm, 53.82±13.41 kg; 9 girls, 15.05±1.30 years, 160.82±3.49 cm, 50.58±10.41 kg). Skinfolds were taken according to standardized procedures: triceps, biceps, subscapular, suprascapular, anterior thigh and medial calf. A 2-way (Country*Sex) Manova was used to assess the differences between country and gender in skinfold patterning.

Results: There was a Country*Sex interaction for the medial calf skinfold ($p=0.028$, $\eta^2=0.130$). Simple effects analysis showed both the US boys (7.64±2.58 mm, $p<0.001$) and girls (9.33±2.12 mm, $p=0.005$) to have lower calf skinfolds than the Spanish girls (15.76±6.05 mm), as did the Spanish boys (8.60±1.84 mm, $p<0.001$). There was a Country main effect for age with the Spanish *taekwondo-in* being older: 16.67±1.46 years vs. 15.24±1.24 years ($p=0.003$, $\eta^2=0.224$). Collapsed over country, the girls had larger absolute skinfolds of the triceps (11.24±2.51 mm vs. 6.95±1.85 mm, $p<0.001$, $\eta^2=0.507$), thigh (15.95±5.43 mm vs. 9.28±2.32 mm, $p<0.001$, $\eta^2=0.404$), and suprascapular (8.06±2.99 mm vs. 5.53±1.71 mm, $p=0.002$, $\eta^2=0.237$).

Conclusions: In addition to sport and sex, ethnicity is also suggested to be a correlate of fat patterning, even in elite young athletes.

Introduction

Gender is suggested to be the most important determinant of total fat accumulation and fat patterning, while the effect of sport should also be taken into account [Malina *et al.* 1982]. For instance, long distance runners have been found to have less fat than swimmers, irrespective of the event, while female athletes in the same sport have more fat than their male colleagues [Wilmore, Costill 2004]. For example, young (15.6 years) female volleyball players had more fat than their male counterparts at all levels of competition [Gabbett, Horgieff 2007].

Although not always statistically significant, sexual dimorphism in body composition in combat sports has also been reported at all levels of competition, regardless of the geographic region. Adult recreational British female taekwondo athletes

(*taekwondo-in*) had more fat than their male colleagues [Chan *et al.* 2003] as did Filipino female varsity taekwondo athletes [Pieter, Bercades 2010]. Toskovic *et al.* [2004] investigated recreational American varsity and club *taekwondo-in*. The authors revealed that in addition to the typical sex differences in body fat, the experienced taekwondo athletes in both males and females had less fat than their beginning counterparts.

At the elite level, adult male *taekwondo-in* had less fat than their female colleagues: 7.5% vs. 12% [Taaffe, Pieter 1990]. The same pattern was reported for elite athletes in karate [Fritzsche, Raschka 2006] as well as in judo [Sertić *et al.* 2006]. Markovic *et al.* [2005] did not find a statistically significant difference in body fat between internationally successful and less successful female *taekwondo-in*, although the former recorded less fat: 15.3% vs. 17.6%.

The detrimental effects of excess fat have also been highlighted [Sinning 1985]. In Italian college combative athletes the females had more fat than their male counterparts [Gualdi Russo *et al.* 1992]. It is suggested to consider sport-specific requirements when evaluating the athletes' relative total body fat [Pieter *et al.* 2006]. For instance, karate athletes have to be able to propel the body through space as fast as possible, as is the case in taekwondo. Excess mass, especially in the form of fat, may be detrimental to performance because of its negative effect on the weight-to-strength ratio [Sinning, 1985].

Although body fat will depend on weight division, combative sports where fast movements are required may most likely call for a low fat mass to enhance the weight-to-strength ratio. Nevertheless, even if fast and slow movements are part of one's sport, such as in pencak silat, a more desirable amount of fat would still be preferable: too much fat will most likely deter the athletes from achieving peak performance in their chosen sport [Sinning 1985].

Research on body composition in young combat sport athletes is scarce, while no studies are available on fat patterning in a language familiar to the authors. At the elite level, girl *taekwondo-in* (15.1 years) were found to have more fat, as expressed by sum of skinfolds, than their male colleagues (16.5 years) [Pieter 1991]. Sexual dimorphism was also reported in Malaysian recreational adolescent [Noorul *et al.* 2008] and child *taekwondo-in* [Erie, Pieter 2009] as far as relative total body fat is concerned.

Fat patterning in adult athletes in combat sports has been done before. For instance, Pieter *et al.* [1998] assessed the fat patterning of Filipino national female judo athletes (*judoka*) and American elite female *taekwondo-in*. The authors reported that triceps and medial calf skinfolds relative to Phantom height (170.18 cm) were larger in the *judoka*.

Pieter *et al.* [2006] investigated fat patterning in Filipino national elite athletes in karate and pencak silat. Collapsed over gender, the *karateka* had a lower anterior thigh skinfold relative to Phantom height than the pencak silat athletes. Collapsed over sport, the males had lower triceps, supraspinale and anterior thigh skinfolds when scaled to Phantom height.

However, to the best of the authors' knowledge, there is no information on fat patterning in young taekwondo athletes. Therefore, the purpose of this study was to compare the skinfold patterning of international elite junior Spanish and American *taekwondo-in*.

Methods

Subjects were members of the junior national teams of Spain (10 boys and 11 girls) and United States of America (9 boys and 9 girls). Skinfold measurements were taken according to Ross and Marfell-Jones (1991) on the right side of the body and included: triceps, biceps, sub-scapular, supraspinale, anterior thigh and medial calf with a Lange skinfold caliper (Beta Technology, Santa Cruz, CA, USA) (American *taekwondo-in*) and a Harpenden skinfold caliper (British Indicators, Luton, UK) (Spanish *taekwondo-in*). All measurements were taken three times, unless the first two were the same, and the median used for statistical analysis.

Data distributional characteristics were verified by the Kolmogorov-Smirnov Test, while skewness and kurtosis coefficients were also calculated. Data that were not normally distributed, skewed and/or kurtotic were log transformed.

To determine differences in skinfold patterning between Spanish and American junior *taekwondo-in*, a 2-way (Country*Sex) Manova was used. It was decided not to use any adjustment of the type 1 error for multiple comparisons [Feise 2002]. The objective was to unearth any possible leads regarding the relationship between the independent and dependent variables [Bender, Lange 2001; Rothman 1990]. The level of significance, then, was set to 0.05.

Results

Table 1 shows the descriptive statistics of the demographic data of the *taekwondo-in*. There was a small Country main effect for age with the Spanish *taekwondo-in* being older: 16.67 ± 1.46 years vs. 15.24 ± 1.24 years ($p = 0.003$, $\eta^2 = 0.224$).

There also was a small Sex main effect for height with the boys being taller: 169.82 ± 11.58 cm vs. 161.56 ± 8.37 cm ($p = 0.016$, $\eta^2 = 0.155$).

Table 2 displays the means and standard deviations of the skinfold measurements. There was a Country * Sex interaction for the medial calf skinfold ($p = 0.028$, $\eta^2 = 0.130$). The probability matrix of the simple effects analysis is shown in Table 3.

Table 4 displays the descriptive statistics for the tricipital, supraspinale, anterior thigh and medial calf skinfolds. Collapsed over country, the girls had larger absolute skinfolds of the triceps ($p < 0.001$, $\eta^2 = 0.507$), anterior thigh ($p < 0.001$, $\eta^2 = 0.404$), and supraspinale ($p = 0.002$, $\eta^2 = 0.237$). There also was a medial calf Sex main effect ($p = 0.001$, $\eta^2 = 0.281$).

Table 1. Means and standard deviations of demographic data of young taekwondo-in

	Spanish		American	
	Boys	Girls	Boys	Girls
Age (years)	16.70 ± 1.49	16.64 ± 1.50	15.44 ± 1.21	15.05 ± 1.30
Height (cm)	173.30 ± 9.68	162.16 ± 6.69	165.94 ± 12.82	160.82 ± 3.49
Weight (kg)	61.88 ± 13.24	54.96 ± 10.60	53.82 ± 13.41	50.58 ± 10.41
RPI (cm.kg ^{0.333})	44.15 ± 1.49	42.95 ± 2.02	44.31 ± 1.31	43.76 ± 1.38

Table 2. Descriptive statistics of skinfolds (mm) of young taekwondo-in

	Spanish		American	
	Boys	Girls	Boys	Girls
Triceps	6.65 ± 1.74	12.01 ± 2.54	7.28 ± 2.02	10.31 ± 2.26
Biceps	3.30 ± 0.63	4.91 ± 1.12	3.94 ± 1.67	4.97 ± 1.99
Subscapular	7.19 ± 1.84	8.30 ± 2.15	7.33 ± 1.00	8.67 ± 2.05
Supraspinale	4.88 ± 1.61	7.63 ± 3.17	6.25 ± 1.60	8.58 ± 2.85
Anterior thigh	9.40 ± 1.82	17.35 ± 6.22	9.14 ± 2.89	14.25 ± 3.97
Medial calf	8.60 ± 1.84	15.76 ± 6.05	7.64 ± 2.58	9.33 ± 2.12

Table 3. Probability matrix of the simple effects analysis of the Country*Sex interaction for the medial calf skinfold (mm)

	US boys 7.64	US girls 9.33	ESP boys 8.60	ESP girls 15.76
US boys 7.64				
US girls 9.33				
ESP boys 8.60				
ESP girls 15.76	<0.001	0.005	<0.001	

Table 4. Means and standard deviations of gender differences in skinfold thicknesses (mm)

Skinfold	Boys	Girls
Triceps	6.95 ± 1.85	11.24 ± 2.51
Supraspinale	5.53 ± 1.71	8.06 ± 2.99
Anterior thigh	9.28 ± 2.32	15.95 ± 5.43
Medial calf	8.15 ± 2.21	12.87 ± 5.65

Discussion

Similar to Malaysian recreational male taekwondo and karate athletes combined [Aiwa, Pieter 2007], the boys in the current study, when collapsed over country, were taller than the girls, while not differing in weight or RPI. Although not reported in the present study, based on the available research it may be hypothesized that the girls may have carried more fat mass [Chan *et al.* 2003; Noorul *et al.* 2008; Pieter 1991; Pieter *et al.* 2006; Toskovic *et al.* 2004], thereby offsetting differences in weight for height ratios or even total body mass. Although the difference in height between boys and girls was small, it may be put forward that this led to more lean mass, since there is a positive relationship between height and lean body mass [Welsman *et al.* 1996].

The differences in skinfold patterning between males and females were expected: men had lower skinfolds at the tricipital, supraspinale and anterior thigh sites. Sexual dimorphism in skinfold patterning was also found in other sports

[e.g.: Carter 1982; Ross, Ward 1984]. However, the effect sizes for more extremity fat in the females are small to moderate. Future studies should use larger sample sizes for each gender by sport.

Filipino female elite *judoka* had proportionally more truncal fat than American elite female *taekwondo-in*, who showed more fat on the extremities [Pieter *et al.* 1998]. It has been suggested that mechanical efficiency may be at the basis of fat patterning that may also be sport-specific [Malina *et al.* 1982; Mueller *et al.* 1982].

Having proportionally low fat at various body parts will surely aid the *taekwondo-in* in accelerating and decelerating rapidly as is required by the nature of the sport. In addition to sport and sex, ethnicity is suggested to be a correlate of fat patterning, even in elite young athletes. Contrary to the present findings, Baumgartner *et al.* [1990] reported that in the general population, the largest difference between Hispanic and White youth (16-18 years) was found in the suprailiac and medial calf skinfolds, with the medial calf skinfold being smaller in Hispanics than in Whites, but the former

had a larger medial calf skinfold than Blacks. In boys, the calf skinfold decreases with age (1-18 years) faster in Hispanics than in Whites or Blacks.

Malina *et al.* [1995] revealed that in adolescent girls (12-17 years), the Asians started losing truncal fat first, followed by Hispanics, Whites and Blacks. Hispanic girls had larger medial calf skinfolds than Blacks and Asians but lower than Whites. With the contradictory results from the previous and present studies, longitudinal research is suggested to help shed light on the difference between studies, especially since Hispanics and Asians showed more truncal compared to extremity fat than the other ethnic groups [Malina *et al.* 1995].

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Słowa kluczowe: dystrybucja tkanki tłuszczowej, sporty walki, młodzi sportowcy

Streszczenie

Cel: Badania wskazują na to, że najważniejszym determinantem ilości tkanki tłuszczowej jest płeć jednakże wpływ uprawianego sportu powinien być także wzięty pod uwagę. Chociaż modelowanie tkanki tłuszczowej w sportach walki było badane wcześniej, nie ma informacji na ten temat w zakresie taekwondo. Stąd celem pracy jest porównanie modelowania fałdu tłuszczowego wśród międzynarodowej elity hiszpańskich i amerykańskich juniorów taekwondo-in.

Metody: Podmiotem badania byli członkowie hiszpańskich drużyn narodowych juniorów (10 chłopców, w wieku 16.70 ± 1.49 lat, wzroście 173.30 ± 9.68 cm, wadze 61.88 ± 13.24 kg; 11 dziewcząt, 16.64 ± 1.50 lat, 162.16 ± 6.69 cm, 54.96 ± 10.60 kg) oraz zawodnicy amerykańskich drużyn (9 chłopców, 15.44 ± 1.21 lat, 165.94 ± 12.82 cm, 53.82 ± 13.41 kg; 9 dziewcząt, 15.05 ± 1.30 lat, 160.82 ± 3.49 cm, 50.58 ± 10.41 kg). Pomiar fałdów skórnych został pobrany według standardowych procedur: triceps, biceps, punkt pod łopatką, okolice kości biodrowej, przednia część uda i przyśrodkowa część łydki. Dwuwymiarowa (Kraj i Płeć) analiza statystyczna wariacji Manova została zastosowana w celu oszacowania różnic w modelowaniu fałdu tłuszczowego w odniesieniu do kraju pochodzenia oraz płci.

Rezultaty: Zaistniało wzajemne oddziaływanie (Kraj*Płeć) w odniesieniu do grubości fałdu tłuszczowego środkowej części łydki ($p=0.028$, $\eta^2=0.130$). Prosta analiza wyników wykazała iż zarówno amerykańscy chłopcy (7.64 ± 2.58 mm, $p<0.001$),

jak i dziewczęta (9.33 ± 2.12 mm, $p=0.005$) mieli mniejszy fałd tłuszczowy łydki od hiszpańskich dziewcząt (15.76 ± 6.05 mm), podobnie było w przypadku hiszpańskich chłopców (8.60 ± 1.84 mm, $p<0.001$). Jeśli chodzi o wiek hiszpańscy zawodnicy *taekwondo-in* byli starsi w porównaniu z amerykańskimi (16.67 ± 1.46 lat oraz 15.24 ± 1.24 lat ($p=0.003$, $\eta^2=0.224$). Na podstawie pozostałych danych dotyczących obu krajów stwierdzono, iż dziewczęta miały większy fałd tłuszczowy tricepsów (11.24 ± 2.51 mm wobec 6.95 ± 1.85 mm, $p<0.001$, $\eta^2=0.507$), udowy (15.95 ± 5.43 mm wobec 9.28 ± 2.32 mm, $p<0.001$, $\eta^2=0.404$) oraz około-biodrowy (8.06 ± 2.99 mm wobec 5.53 ± 1.71 mm, $p=0.002$, $\eta^2=0.237$).

Konkluzje: Autorzy pracy doszli do wniosków popartych badaniami, iż oprócz rodzaju sportu i płci istnieje korelacja pomiędzy modelowaniem fałdu tłuszczowego i narodowością, nawet wśród elity młodych sportowców.