Research Report

Anthropometric profile of elite Filipino fencers

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ABSTRACT

Objective: This study established baseline kinanthropometric data for Filipino elite fencers. Since there are few anthropometric data on elite fencers, the data will fill the paucity of information in our database. The profile may be utilized to monitor, evaluate and modify training programs for competitive advantage in international games. ***Methods:*** Anthropometric measurements were taken from 24 elite Filipino fencers who were members of the national team and training pool of the different weapons in fencing. Height, weight, six skinfold sites (SUM6), somatotype and segment length were measured and descriptive analysis was used. ***Results:*** The results show that male Filipino sabre players and female epee fencers were taller than other teams. Male and female sabre players were also heavier while epee players had wider arm span and higher leg length. Our female elite fencers had more body fat although their individual somatotypes were variable. The male Filipino elite players were mesomorphic similar to their international counterparts. However, the ratio of height to segment length, important as a factor in maintaining balance, agility and speed, appears to be the same for all players. ***Discussion:*** This work establishes baseline kinanthropometric profile that adds to database for elite fencers. However, while absolute terms on height, weight, segment lengths, etc. may be important, the data should be re-evaluated. In addition, there are perhaps other factors that give competitive advantage to fencers when they play in national and international games. Additional research is therefore recommended since kinanthropometric characteristics, although important, may just be one of the factors that play important roles in winning medals in this sport. ***Conclusion:*** This is the first study in the Philippines that examined in detail kinanthropometric measurements of elite Filipino fencers. The study shows that male and female elite players as well as players in different events show some differences in their profiles. Additional studies should be done to give a more complete kinanthropometric profile of our fencing teams.

Keywords: *kinanthropometry, fencing, anthropometry, sports*

INTRODUCTION

Genetic and nutritional factors are important in assessing how athletes will perform and studies on physique correlated to performance is very important in assessing sports competency of an individual**.** Thus, anthropometric measurements have been taken from local and foreign athletes of various sports to assess the association of form and structure to performance. These were studies done on *pencak silat* and *karate*[1], *judo*[2], badminton[3, 4], swimming[5], wrestling[6], taekwondo[7], powerlifting[8], judo and karate[9] and modern pentathlon[10], weightlifting and powerlifting[11] and ballet dancing[12] among others.

However, there are only few studies both local and international done on fencing as compared to other sports. In the Philippines, Cabotage[13] took anthropometric measurements, particularly girths, segmental lengths, and skinfolds from the front thigh of athletes to detect differences in leg volume between the dominant and non-dominant legs. He found no significant difference in the lean thigh volume of these legs. Other studies on fencing include correlation of cardiovascular fitness level and fencing[14] in which it was observed that the cardiovascular level of the athletes had no significant relationship with their fencing achievement. Types and incidence of knee injuries, which are common to fencers because of their postures and movements, in

addition to the nature of the sport, were likewise studied.[15]

While the aforementioned studies are useful, a more comprehensive application of anthropometry is yet to be done. Fencing has become one of the Philippines' most successful sports in terms of international medals won. In spite of this, there is, at present, no extensive study conducted regarding the anthropometric profile of elite Filipino fencers which may serve to provide baseline data for reference purposes, i.e. to serve as guide in selecting athletes for competition. It is important to note, however, that the Philippine Center for Sports Medicine (PCSM) has been conducting physical examinations which include some anthropometric data. Interpretation of findings and profiling, though, has not been done to date.

The physical characteristics of elite Filipino fencers in terms of body size, skinfolds (SUM6), somatotype and segment lengths (arm span, leg length) have not yet been extensively investigated. The sport is gaining general appreciation here in the Philippines and having studies that the public and officials can refer to may help in improving our performance in this sport. Specifically, elite athletes' measurements may be of use in the identification of potential contenders.

This study therefore was undertaken to fill up the paucity of information on Filipino fencers with regards to a complete anthropometric profile. The significance of this study is related to establishing baseline data for athletes, specifically fencers, coaches and sports scientists. Moreover, the results may be utilized to monitor, evaluate, and modify training programs, while serving as the minimum criteria for selecting athletes. The study also serves as a starting point for further investigations relevant to improving athlete performance in fencing and other sports.

METHODOLOGY

This study employed a descriptive type of research and primarily measured the mean body size, sum of six skinfolds, somatotype, and segment length of elite Filipino fencers.

Subjects

The subjects of this study were confined only to elite Filipino fencers who were members of the national team and training pool of the different weapons in fencing (foil, epee, and sabre) for the 2nd quarter of 2003. There were 24 fencers, 16 males and 8 females, with ages ranging from 19 to 27 years old, all included in the study. Mean age was determined to be 21.85 $\pm$ 2.2y. These fencers were training at least three times a week at the Fencing Hall of the Philsports Complex (formerly ULTRA) at Pasig City.

At the time when measurements were taken, the elite fencers were not competing in any national or international sports event but were preparing for future competitions. Measurements were done in between trainings or while the fencers were resting. Prior informed consent was obtained from all subjects included in the study.

Anthropometric Measurements

Anthropometric measurements[16] and the Heath-Carter[17] method of somatotyping applied by Ross and Marfell-Jones[16] for Sports were followed. These methods are used by the International Society for the Advancement of Kinanthropometry (ISAK) and had been validated by Carter[18] with measurements obtained for 1,114 male and 456 female American and South African athletes from seven (7) team sports namely basketball, rugby, soccer, swimming, hockey, water polo and volleyball, as well as Bourgois et al[19] for 383 male junior rowers.

The same measurements were employed by Palabrical[2] in studying fat and skinfold patterns and physique of female Filipino judo athletes and Callanta[3] for elite badminton players. In the present study, the following data were obtained: subjects' height, weight, six skinfold measurements (triceps, subscapular, suprailliac, abdominal, front thigh, medial calf), two bone widths (epicondylar humerus and femur), two girths (flexed bicep and calf), and segment lengths (arm span and leg length).

All skinfold measurements were taken in triplicates at the same site using the same equipment and by only the researcher. All skinfold, girths, and widths measurements were taken on the right side except for the umbilical skinfold which was taken on the left side[16, 20].

Height (stretch stature) of the barefoot subject was measured by a wooden stadiometer, while weight was taken using a Detecto Weighing Scale. All skinfold thicknesses were taken with the Slimguide skinfold caliper. The caliper was applied 1 cm distally from the left thumb and

index finger. Measurement included a double layer of skin and the underlying adipose tissue but not the muscle.

Somatotype
A Gullic Tape was used to measure the girths, maximum arm girth of a tensed arm, and perimeter of calf, humerus, and femur. Somatotype was computed according to equations derived from data used by Heath and Carter.[21]

Segment Length
A Gullic Tape was used to measure the leg length and arm span of the athletes. Leg length was measured as the difference between the standing height and sitting height. Arm span was taken as the distance from the tips of the two middle fingers.[22] Sitting height was measured with the subjects sitting on a stadiometer. Subjects took a deep breath and the measurement was made just as the subject exhales.

Reliability of Measurements
Test-retest reliability of measurements were evaluated using the % technical error of measurement (TEM)[17].

Statistical Analysis
A descriptive analysis was used with the mean and standard deviation being computed for all data to determine the body size (height and weight), sum of six skinfolds, somatotype components, and segment lengths using SPSS.

RESULTS

Anthropometric measurement:
Height and Weight
Body size measurements show that the mean height and weight of the male elite fencers were 168.7±5.1 cm and 64.2±7.2 kg, respectively while the females had mean height and weight of 161.9±9.2 and 55.7±7.3, respectively. These results are shown in Tables 1 and 2. The findings of this study are in agreement with findings shown in PCSM records starting 1995 - 2003 and Callanta[23] on UP varsity athletes.

The Filipino fencers studied were shorter than international fencers[24, 25] as well as the Montreal Olympic athletes who had a mean height of 183.6 ± 7.4 cm. Filipino fencers studied were also lighter than international players as well as the Olympians whose mean weight was 77.6 ± 8.1 kg.

Table 1. **Kinanthropometric profile of Filipino Male Elite Fencers** (Mean ± SD)

		Foil	Epee	Sabre	Average	%TEM*
Body Size	Height, cm	167.45 ± 5.8	168.9 ± 4.6	170.0 ± 5.4	168.7 ± 5.1	0.32
	Weight, Kg	62.1 ± 7.4	63.8 ± 8.4	67.3 ± 6.1	64.2 ± 7.2	0.14
Segment Length	Arm Span, cm	170.1 + 3.3	179.0 ± 4.3	174.7 ± 7.4	174.3 ± 6.1	0.76
	Leg length, cm	78.2 ± 1.6	82.2 ± 2.8	82.7 ± 3.5	80.9 ± 3.3	0.41
Skinfolds	Triceps, mm	9.5 ± 2.6	9 ± 3.2	11.2 ± 2.8	9.9 ± 3.1	2.3
	Subscapular, mm	11.8 ± 3.4	10.4 ± 1.2	12.4 ± 2.6	11.5 ± 2.8	4.5
	Suprailiac, mm	10.8 ± 3.8	9.4 ± 4.4	13.6 ± 3.7	11.2 ± 4.5	4.6
	Umbilical, mm	14.3 ± 4.5	12.8 ± 3.9	14.6 ± 3.9	13.9 ± 4.3	1.3
	Thigh, mm	9 ± 2.1	9.2 ± 3.1	10.4 ± 2.2	9.5 ± 2.6	5.06
	Calf, mm	6.7 ± 0.5	7.6 ± 3.5	9.0 ± 1.4	7.7 ± 2.4	4.3
	SUM6SKF	62.1 ± 14.3	58.4 ± 13.5	71.2 ± 12.7	63.7 ± 13.5	
Somatotype	Endomorphy	3.25 ± 0.9	2.9 ± 0.8	3.78 ± 0.77	3.3 ± 1.0	
	Mesomorphy	4.2 ± 0.9	4.52 ± 0.6	3.98 ± 0.8	4.2 ± 0.8	
	Ectomorphy	2.5 ± 0.9	2.5 ± 0.8	2.1 ± 0.7	2.4 ± 0.9	

*Technical Error of Measurement = $(\sum d^2/2n)^{0.5}$; % TEM = 100 (TEM/grand mean); TEM for skinfolds should be about 5%, for breadths and girths, 1% and for height about 0.5%[17]

Table 2. **Kinanthropometric profile of Filipino Female Elite Fencers (**Mean ± SD)

		Foil	Epee	Sabre	Average	%TEM*
Body Size	Height, cm	157.6 ± 2.2	167.1 ± 13.7	160.5 ± 8.3	161.9 ± 9.2	0.4
	Weight, Kg	50.2 ± 4.7	56.1 ± 6.4	63.5 ± 6.2	55.7 ± 7.3	0.5
Segment Length	Arm Span, cm	158.6 ± 2.3	171.4 ± 16.9	162.2 + 7.1	164.3 + 11.3	0.3
	Leg length, cm	73.6 ± 2.4	78.9 ± 9.9	76.1 ± 9.8	76.2 ± 7.0	0.82
Skinfolds	Triceps, mm	12.3 ± 2.6	12.7 ± 2.1	16.5 ± 0.5	13.5 ± 2.9	5.03
	Subscapular, mm	10.3 ± 3.4	11 ± 1.4	14.5 ± 1.5	11.6 ± 3.1	3.5
	Suprailiac, mm	9.7 ± 3.8	9.7 ± 0.5	16.5 ± 2.5	11.4 ± 4.2	0.5
	Umbilical, mm	13.0 ± 2.0	12.0 ± 0.8	12.5 ± 1.5	12.5 ± 2.1	4.5
	Thigh, mm	14 ± 2.2	10.0 ± 5.2	12.0 ± 0	12.0 ± 4.3	4.9
	Calf, mm	10 ± 1.4	11.3 ± 2.5	14.0 ± 1.0	11.5 ± 2.7	0.53
	SUM6SKF	69.3 ± 16	66.7 ± 8.8	86 ± 0	72.5 ± 8.3	
Somatotype	Endomorphy	3.3 ± 1.0	3.4 ± 0.4	4.75 ± 0.05	3.7 ± 1.0	
	Mesomorphy	2.8 ± 0.9	2.6 ± 0.5	4.5 ± 0.5	3.1 ± 1.1	
	Ectomorphy	2.8 ± 1.1	3.4 ± 1.2	1.05 ± 0.25	2.6 ± 1.5	

*Technical Error of Measurement = $(\sum d^2/2n)^{0.5}$; % TEM = 100 (TEM/grand mean); TEM for skinfolds should be about 5%, for breadths and girths, 1% and for height about 0.5%[17]

The mean height and weight by event presented in Tables 1 and 2 show that among male elite Filipino fencers, sabre fencers were the tallest and heaviest in the study group. In females, the epee fencers were the tallest although the sabre fencers were also found to be the heaviest.

A similar finding was obtained from data for fencers who competed during the Cuban and Hungarian events. The sabre fencers were also shown to be the tallest players among fencers with an average height of 178.3 ± 5.2 cm and 178.4 ± 5.7 cm respectively.

Anthropometric measurement:
Segment Lengths
The mean arm span and leg length of male elite fencers were determined to be 174.3±6.1 cm and 80.9±3.3 cm, respectively while for females, mean arm span and leg length was 164.3±11.3 and 76.2±7.0, respectively. Among the fencers, the highest arm span and leg length were the epee players although for females, there is not much difference between leg length of epee and sabre fencers. In addition, epee fencers had the widest arm span and highest leg length.

Nonetheless, the ratio of arm span to leg length (Table 3) that is critical in maintaining balance was the same for all fencers.

Anthropometric measurement:
Body composition
The mean (X) and standard deviation (SD) of the measurements for the sum of 6 skinfolds (SUM6) of the triceps, subscapular, suprailiac, umbilical, thigh, and calf of elite male and female Filipino fencers are also presented in tables 1 and 2.

The mean sum of six skinfolds (SUM6) for the male and female elite fencers was 63.7±13.5 mm and 72.5±8.3, respectively. The SUM6 gives the relative "fatness" of the individual being studied.

It was also noted that the mean sum of six skinfolds for females included in this study was lower than the sum of six skinfolds of elite female fencers who were measured prior to the 1998 Asian Games. In 1998, physical testing of Filipino elite female fencers gave a SUM6 of 100.64±26.5.

The mean SUM6 of male Filipino fencers at 63.7±13.5 mm which was higher than the

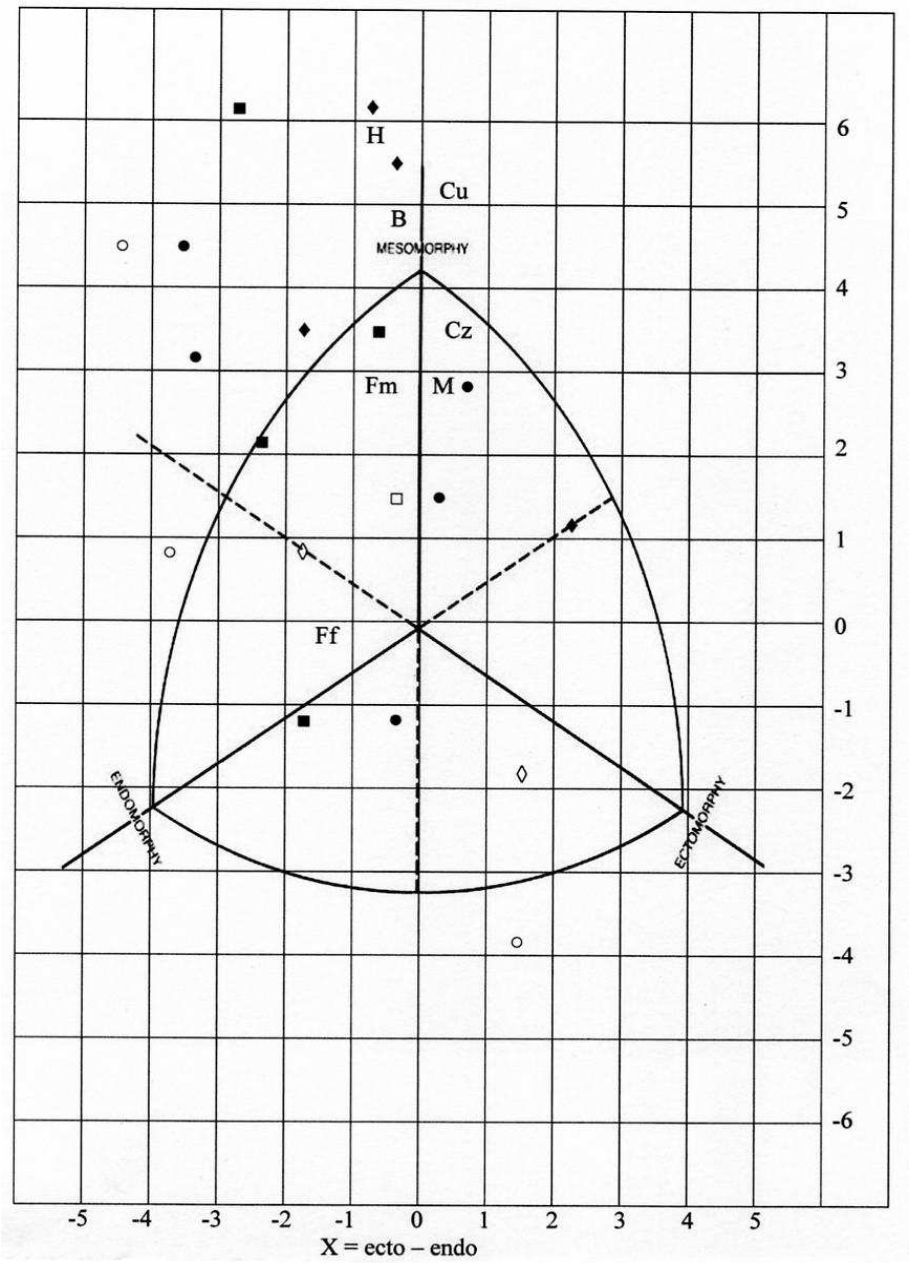
reported SUM6 of fencers in the Montreal Olympic Games[26] which was 59.8 ± 24.07 mm.

Anthropometric measurements: Somatotype

The over-all somatotype rating showed that male elite fencers were mesomorphic while females were shown to have high variability (fig. 1).

The average tends to show that female fencers were more endomorphic (Table 2). However, this conclusion cannot be made considering the limited sample size studied. Moreover, all male teams were mesomorphic, while all female teams were endomorphic with sabre being endo-mesomorphic.

Fig. 1. Somatochart of Filipino Elite Fencers



○, open circle = female, foil
●, closed circle = male, foil
□, open square = female, sabre
◊, open diamond = female, epee
♦, closed diamond = male, epee
■, closed square = male, sabre

Fm= Mean, male
Ff = Mean, female

M = Montreal Olympics, 1976 [26]
Cz = Czechoslovakia Games, 1971[26]
B = Bolivar Games. 1981[24, 25]

Cu = Cuba, 1976-1980[24, 25]
H = Hungary[24, 25]

The results for the male fencers were consistent with those of international players that competed in various Games (Bolivar, Hungary, Cuba, Czechoslovakia, and Montreal)[24, 25] who were also mesomorphic (fig. 1).

DISCUSSION

Anthropometric or kinanthropometric measurements is a useful tool in determining specific desirable parameters for athletes which is important in assessing an athlete's health, risk of disease or injury, diet, and effectiveness of training programs. The information will then serve as a guide in formulating the criteria for choosing athletes on the basis of optimal physique for competitive advantage. The data will help improve athlete selection and training modifications which in turn will produce better performance.

In addition, the fencers' anthropometric measurements done during peak performance may be used as a gauge from which fencers and officials may be able to assess and compare their personal profile with world- and Olympic-caliber fencers. In the Philippines at present, the strongest basis for inclusion in the national pool is the quarterly ranking taken from results of monthly open competitions.

The relevance of kinanthropometry was justified in other sports. Profiles of athletes from different athletic events are available in sports centers and also via the worldwide web. These have become the basis for other researches such as correlating athletes' anthropometric profile with their performance, position in a team like in rugby[27] and basketball,[28] or with their classification as in wrestling, powerlifting and bodybuilding.[29] Carter and Heath[17, 30] wrote that "Physical activities that place a premium on strength, power, speed, or endurance, confine successful participation to the somatotypes (physiques) best suited or best developed for the physical requirements of the activity."

Ketlinski and Pickens[31] studied the relation of success in fencing with speed and accuracy of fencing movements. Speed and accuracy were correlated with kinanthropometric data thus their study included body size measurements in the athletes' profile. They found that epee fencers were taller and heavier, with an average height and weight of 186.0 ± 2.27 cm and 78.4 ± 13.08 kg, respectively, than their foil and sabre counterparts. Hirata [26] studied the average height and weight of Olympic players in the Montreal Games and listed the ideal and critical height in fencing for Olympic selection. This, however, is old data and has not been validated; this also was not strictly followed by officials and other researches. Nonetheless, if Hirata's recommendation is to be followed, then all male and female Filipino elite fencers are shorter than the recommended critical height.

Segment lengths greatly affect the performance of athlete. But while elite Filipino fencers studied had mean arm span that conforms to world standards, the leg length of Filipino fencers was shorter than that of the Montreal athletes by approx. 8.5 cm. This is a genetic trait which Filipinos, being a race of short people, has to overcome through more intensive training. In running, stride length and stride rate are the determinants of running velocity, and leg length has been demonstrated to be directly and proportionally related to stride length, although the relationship is not perfect.[31]

When compared by event, the female epee fencers were found to be taller, with a wider arm span and a longer leg length. On the other hand, among the males, the sabre fencers were taller, although the epee players had wider arm span. Leg length between sabre and epee players were not however much different.

It is interesting to note that the ratio of the parameters taken show that males and females had more or less equal height: arm span, height: leg length and arm span: leg length ratio (Table 3). Fencing is one of the games that rely on speed, accuracy and agility of players and maintaining balance is important in the play. It may thus be important to investigate segment length data and their relationship to each other. Obviously, despite being taller, male fencers do not have greater competitive advantage than the females since the ratio of height to segment data are equal.

In sports, establishing an optimal weight for peak performance is an important aspect in preparing an athlete for competition.[32] Body composition measurement has several functions. Clinically, it may be utilized to assess total and regional body fat to identify health risks associated with excessively low or high levels of total body fat. In sports, body composition data may be used to justify formulation of dietary recommendations and exercise prescriptions to meet appropriate

Table 3. **Ratio of kinanthropometric parameters of Elite Filipino fencers**

	Foil		Epee		Sabre		Average	
	Male	Female	Male	Female	Male	Female	Male	Female
Height: weight	2.7	3.2	2.65	2.98	2.63	2.53	2.63	2.91
Height: arm span	0.98	0.99	0.94	0.97	0.97	0.99	0.97	0.99
Height: leg length	2.14	2.14	2.05	2.12	2.06	2.11	2.09	2.12
Arm span: leg length	2.18	2.15	2.18	2.17	2.11	2.13	2.15	2.16
Height: SUM6SKF	2.7	2.27	2.89	2.51	2.39	1.87	2.65	2.23

weight for competition.[29] Likewise, evaluation of body composition can provide valuable information on the progress of an individual during an exercise program. This is significant in providing indices to body fatness and therefore a means of describing relatively subtle changes in energy balance which are not readily apparent from measuring body mass alone but which have the potential to influence performance or, in the longer term, health.[33]

Performance in various motor and sport skills is highly correlated with lean body mass and relative body fat.[34] During an intensive training program, the body density can increase which is indicative of a reduction in body fat content that, at the same time, would be supported by a reduction in the skinfold thicknesses observed.[33]

The average of six skinfolds (SUM6) of the male and female elite Filipino fencers studied was 63.7 ± 13.5 mm and 72.5 $\pm$ 8.3 mm, respectively. These data show the female tendency to have greater body fat content. Generally, a relatively low body fat is desirable to optimize physical performance in sports requiring jumping and running. Studies[35] on lightweight rowers as well as other sports[36] also show that for some sports, it is the actual percentage of body fat that determines performance, i.e., a leaner athlete would perform better in competitions. A large muscle mass enhances performance in strength and power activities.

Usually, athletes and physically active individuals are leaner than sedentary individuals, regardless of gender with larger muscle mass but less body fat. Comparing body fat between genders, females have relatively greater body fat than male athletes in a given sport, and the average body fatness depends on the type of sport and the athlete's position[37]. Tables 1 and 2 show that sabre players have more body fat which may be due to the fact that their games are shorter and hence less fat is burned. Conversely, because of the longer playing period, epee players were shown to have the lowest value for the SUM6SKF.

In anthropometric surveys, the skinfold method is administered more commonly because they provide a relatively simple and non-invasive method of estimating general fatness. Likewise, it has a major use in the characterization of the regional distribution of subcutaneous adipose tissue in the trunk and extremities[38,39]. The data obtained is used in establishing anthropometric profiles of a specific population.[27]

Skinfolds predict either total body density (Db, which is the total body mass expressed relative to total body volume) or relative body fat (%BF, fat mass expressed as a percentage of total body weight). The individual skinfold and sum of skinfolds from multiple sites are inversely related to Db; that is, the greater the sum of skinfolds, the lower the body density, indicating a greater %BF for the individual.[29]

The Heath-Carter[18] method of somatotyping is the most commonly used method to date. Somatotype ratings revealed that the male elite Filipino fencers studied were mesomorphic and less ectomorphic while females had variable somatotypes. Nonetheless, on the average, females were endomorphic with sabre players being meso-endomorphic which means that the players have a propensity for being fat and heavy set which could influence agility.

Coaches, from the start, scout for individuals or athletes for events with specific characteristics on the basis of their observation and experience. Although it is not yet an established criterion in fencing, epee coaches prefer, for instance, taller fencers for their advantage at play due to longer reach. Then nutrition and programs are undertaken to include fencing workout and weight training to give players a competitive edge internationally. This work shows that perhaps rather than absolute values for body size, the ratio of the different anthropometric data should be given more consideration in choosing athletes

that have greater chances of winning their events. In addition, since there were only 26 elite fencers representing our fencing pool studied, it is recommended that measurements include more athletes including those that are not included in the elite pool. In addition, follow up studies through several years should be done to validate the current data. Nonetheless, since the methods that were used had been validated for various athletes including Filipino judo and badminton players, and TEM is within the valid range, the findings of this study could be considered as part of baseline data to fill in the paucity of information for Filipino fencers, and serve as reference for coaches, trainors and subsequent researches.

CONCLUSION

In conclusion, kinanthropometric profiles obtained of elite Filipino fencers show that while the male elite fencers studied are taller, heavier and are more muscular than their female counterparts, the height: segment lengths and segment length ratio are the same for males and females. The female exhibited a greater sum of six skinfolds indicative of greater subcutaneous adipose tissue stores than their male counterparts.

These results could be explained as due to genetic, gender or nutritional factors or that the male fencers may have been performing a more intense training program, than their female counterparts. Our male elite fencers are also mesomorphic while the female fencers show individual variations in somatotype.

These data are important in devising programs to improve these measurements so as to have a competitive edge internationally. Nonetheless, sixteen (personal communication) of the elite players have won gold medals in their respective events in Asian tournaments while the others are ranked 4^{th}-5^{th} in national ranking. Thus, the success of a fencer may be a cumulative effect of genetic attributes, physical and cardiovascular fitness, psychological make-up, nutritional status, and sports-specific training programs.

However, kinanthropometric measurements, somatotype and body composition remain a prerequisite in most sports for an athlete's optimal performance[10]. Moreover, the human physique is the more apparent and quantifiable evidence of the adequacy and effectiveness of the factors considered. Nonetheless, it is worthwhile to examine the other factors that may be contributing to the regional success of Filipino fencers.

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REFERENCES

1. Pena T, Pinlac V, Bercades L. Body Composition of Filipino Combative Athletes. In: Luigi Bercades, *The Measure of Filipino Athlete.* UAP: Philippine Center for Sports Medicine (PCSM) Databank. 1994. p. 19-20.
2. Palabrica J. *Kinanthropometric Profile of Elite Filipino Female Judo Athletes*. [Masters Thesis] University of the Philippines-Diliman. 1994.
3. Callanta H, Arroyo ER, Rodrigo R. Physique of Elite Badminton Athletes. In Luigi Bercades, *The Measure of Filipino Athletes.* UAP; 1994. p. 38-39.
4. Dela Cruz E. Fat and Body Composition of Elite Badminton Players. In: Luigi Bercades, *The measure of Filipino Athlete* UAP; 1994. P. 42-43.
5. Rodrigo R. Body Build of Male and Female National Swimmers. In: Luigi Bercades, *The Measure of Filipino Athlete.* UAP. 1994; p. 46-47.
6. Madrigal N. *Kinanthropometric Profile of Novice and National Class Wrestlers*. Unpublished [Masters Thesis]. University of the Philippines-Diliman. 1999.
7. Mateo C. *Somatotype and Body Composition of Taekwondo Practitioners*, [Masters Thesis] University of the Philippines-Diliman. 2001.
8. Santos M. *Anthropometric Tendencies of Elite Male Filipino Powerlifters*. [Unpublished Thesis]. University of the Philippines-Diliman 2002.
9. Claessens A, Beunen G, Lefevre J, Mertens G and Wellens R Body structure, somatotype and motor fitness of top-class Belgian judoists and karateka. A comparative study, in T. Reilly, J. Watkins and J. Borms (eds.), *Kinanthropometry III*. London: E. & F. N. Spon; 1986. p. 53 – 57.
10. Claessens A L, Hlatky S, Lefevre J, Holdhaus H. The role of anthropometric characteristics in modern pentathlon

performance in female athletes, *Journal of Sports Sciences* (JSS). 1993. 12(4).
11. Bale P and Williams H. An anthropometric prototype of female power lifters. *Journal of Sports Medicine.* 1987. **27**:191- 196.
12. Dolgener FA, Spasoff TC and St. John WE. Body build and body composition of high ability female dancers. *Research Quarterly*. 1980. 51 (4**)**: 599-607.
13. Cabotage E. Bilateral Comparison of Leg Volume of Fencers. In: Luigi Bercades, *The Measure of Filipino Athlete.* UAP; 1994. p. 13-14.
14. Dioquino A. *Relationship of Cardiovascular Fitness Level to Fencing Achievements*, [Masters Thesis] University of the Philippines-Diliman. 1993.
15. Gamallo M. *Types and Incidence of Knee Injuries Sustained by PAFA Members from January 1996- January 2000.* [Thesis] College of Allied Medical Professions, University of the Philippines- Manila. 2000.
16. Ross WD and Marfell-Jones MJ. Kinanthropometry. In: J.D. MacDougall, H.A. Wenger & H.J. Green, *Physiological Testing of the High-Performance Athlete 2nd Ed.* Champaign, IL: Human Kinetics Books; 1991. p. 251-254.
17. Carter JEL. The Heath-Carter Anthropometric Somatotype Instruction Manual. Dept. of Exercise and Nutritional Sciences, San Diego State Univ. USA. http://www.somatotype.org/Heath-CarterManual.pdf
18. Carter, JEL. Anthropometry of Team Sports. In: Kinanthropometry VIII: Proceedings of the 8th International Society for the Advancement of Kinanthropometry Conference. Reilly, T and Marfell-Jones, M. Routledge, 2003. p. 117-130.
19. Bourgois J, Claessens AL, Vrijens J, Philippaerts R, Van Renterghem B, Thomis M, Janssens M, Loos R, and Lefevre J. Anthropometric Characteristics of Elite Male Junior Rowers. *British Journal of Sports Medicine*. 2000. 34, 213-216.
20. Callaway CW, Chumlea WC, Bouchard C, Himes JH, Lohman TG, Martin AD, Mitchell CD, Mueller WH, Roche AF, and Seefeldt VD (1988). Circumferences. In: Lohman T, Roche A, and Martorell R. *Anthropometric Standardization Reference Manual.* USA: Braun-Brumfield, Inc.; 1988. p. 39-54.
21. Heath BH and Carter JEL. A modified somatotype method. American J. Physical Anthropology. 1967. 27, 57-74.
22. Johnson B and Nelson J. *Practical Measurements for Evaluation in Physical Education*, 4th Ed. NY (New York): Macmillan Publishing Company Inc.; 1986.
23. Callanta HP. Kinanthropometric Profile of the University of the Philippines Varsity Athletes (longitudinal study). 2002. In H. Callanta and D. Bercades, Kinetika, 30-35.
24. Carter JEL. Somatotypes of Montreal Olympic Athletes. *Medicine Sport.* 1982a. **16**: 53-80.
25. Carter JEL. *Physical Structure of Olympic Athletes.* S. Karger. Carter, J.E.L. & Heath, B. H. (1990). *Somatotyping – development and applications.* Cambridge: Cambridge University Press; 1982b.
26. Hirata K. Selection of Olympic Champions. Tokyo: Hirata Inst.; 1979.
27. Carlson BR, Carter JEL, Patterson P, Petti K, Orfanos SM and Noffal G J. Physyque and motor performance characteristics of US national rugby players. *Journal of Sports Sciences.* 1994. **12**: 403-412.
28. Ackland TR, Schreiner AB, Kerr DA. Absolute size and Proportionality characteristics of World Championship female basketball players. *Journal of Sports Sciences*. 1994. **12**: 485-490.
29. Heyward V H and Stolarczyk LM. *Applied Body Composition Assessment.* USA: V.H. Heyward & L.M. Stolarczyk 1996.
30. Carter JEL. *The Heath-Carter somatotype method*. San Diego State University Syllabus Service, San Diego. 1980.
31. Ketlinski R. and Pickens L. Characteristics of male fencers in the 28th annual NCAA fencing championships. *Research Quarterly.* 1973. **44**: 434-439.
32. Wilmore JH, Frisancho RA, Gordon CC, Himes JH, Martin AD, Martorell R, and Seefeldt VD. Body Breadth Equipment and Measurement Techniques. In: Lohman T, Roche A, and Martorell R. *Anthropometric Standardization Reference Manual.* USA: Braun-Brumfield, Inc.; 1988. p. 27-38.
33. Jones PRM and Norgan NG. Anthropometry and the assessment of body composition. In: Harries M, Williams C, Stanish WD, Micheli LJ, eds. Oxford Textbook of Sports Medicine, 2nd ed. Oxford: Oxford University Press; 1998: 207-221.
34. Boileau RA and Lohman TG. The measurement of human physique and its effect on physical performance. 1977. *Orthopedic Clinics North America.* **8**: 563-581.
35. Slater GJ, Rice AJ, Mujika I, Hahn AG, Sharpe K and Jenkins DG. Physique traits of lightweight rowers and their relationship to

competitive success. British J. Sports Med. 2005. 39: 736-741.

36. Hawley J and Burke L. Changing body size and shape. In: Peak Performance: Training and Nutritional Strategies for Sports. Allen and Unwin; 1998. p. 233-260.
37. Wilmore JH. Body composition in sport and exercise: Directions for future research. *Medicine and Science in Sports and Exercise,* 1983. 15: 21-31.
38. Harrison GG, Buskirk ER, Carter JEL, Johnston FE, Lohman TG, Pollock ML, Roche AF, and Wilmore JH. Skinfold Thicknesses and Measurement Technique. In: Lohman T, Roche A, and Martorell R. *Anthropometric Standardization Reference Manual.* USA: Braun-Brumfield, Inc.; 1988. p. 55-70.
39. Lohman TG. Anthropometry and Body Composition. In: T. Lohman, A. Roche and R. Martorell, *Anthropometric Standardization Reference Manual.* USA: Braun-Brumfield, Inc.; 1988. p. 125-129.