ORIGINAL ARTICLE

Somatotype analysis of Korean combat sport athletes based on weight divisions

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C Statistical Analysis
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Ji-Woong Noh[1ABCD], Seung-Min Yang[1BCD], Ju-Hyun Kim[2BE], Jeong-Uk Lee[3BE], Mee-Young Kim[1B], Lim-Kyu Lee[1B], Byoung-Sun Park[1BE], Won-Deok Lee[1B], Yong-Sub Shin[1B], Doo-Ho Kim[1B], So-Jung Kim[1B], Il-Hyun Kim[1B], Taek-Yong Kwak[4BE], Tae-Hyun Lee[5BE], Ju-Young Kim[5BE], Junghwan Kim[6ABCDE]

[1] Laboratory of Health Science & Nanophysiotherapy, Department of Physical Therapy, Graduate School, Yongin University, Yongin, Republic of Korea
[2] Department of Physical Therapy, College of Health Welfare, Wonkwang Health Science University, Jeollabuk-do, Republic of Korea
[3] Department of Physical Therapy, College of Health Science, Honam University, Gwangsan-gu, Republic of Korea
[4] Department of Taekwondo Instructor Education, College of Martial Arts, Yongin University, Yongin, Republic of Korea
[5] Department of Combative Martial Arts Training, College of Martial Arts, Yongin University, Yongin, Republic of Korea
[6] Department of Physical Therapy, College of Public Health & Welfare, Yongin University, Yongin, Republic of Korea

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Abstract

Background and Study Aim: It is well established that somatotypes are defined by the physical characteristics of the body. However, the somatotype results of Korean combat sport athletes have not yet been established. The purpose of study was the somatotype of Korean combat sport athletes based on body weight divisions and physical characteristics in relations the practice of training and sport rehabilitation.

Material and Methods: This study consisted of 40 judo, 32 *ssireum*, 31 taekwondo (*gyorugi*), 20 taekwondo (*poomsae*), 23 boxing, and 13 wrestling elite athletes. The participants were divided into four weight divisions: light weight (–55 to –74 kg), middle weight (–75 to –94 kg), heavy weight (–95 to –114 kg), and super heavy weight (+115 kg). Somatotypes measurements were performed using a Heath and Carter's modified somatotype method.

Results: *Ssireum* athletes had higher endomorphic and mesomorphic characteristic values and lower ectomorphic characteristics compared to other athletes. Somatotype component values for judo and wrestling athletes were similar. *Gyorugi* athletes had higher ectomorphic values than other athletes and were taller. Values of all components among the *poomsae* athletes were balanced. Boxing athletes had the same endomorphic and ectomorphic values and higher mesomorphic characteristic values. Differences between the sports were more significant in the lower- and middle-weight categories compared to the heavy- and super-heavy-weight categories. For all combat sports, higher weight divisions included higher endomorphic and mesomorphic values and lower ectomorphic values compared to lower weight categories. Correlations between endomorphic characteristics and body weight were significant among all athletes except for *gyorugi* athletes. Correlations between mesomorphic characteristics and body weight were significant among judo, *ssireum*, boxing, and wrestling athletes, but taekwondo athletes did not show any correlation. The correlation between ectomorphic characteristics and body weight were significantly negative among judo, *ssireum*, *gyorugi*, boxing, and wrestling athletes and negative among *poomsae* athletes.

Conclusions: Almost all combat sport athletes have mesomorph body types except for taekwondo athletes, and the somatotypes of athletes were influenced by the type of sport and weight divisions. Therefore, injured or ahead-of-the-game elite combat athletes require different methods of rehabilitation and training based on sport type and body weight, and further studies are required to assist in proper training for athletes returning from injury and to aid in sport rehabilitation.

Key words: boxing • judo • mesomorphic characteristics • ssireum • taekwondo • weight divisions • wrestling

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Author's address: Kim Junghwan, Department of Physical Therapy, College of Public Health & Welfare, Yongin University, Yongin 17092, Republic of Korea; e-mail: junghwankim3@yongin.ac.kr

INTRODUCTION

Combat sports are popular worldwide, with boxing and wrestling being the oldest combat sports featured in the Olympics [1-4]. Judo and taekwondo are traditional combat sports in East Asia and have also received significant attention during the Olympic games [5-11]. Every country has traditional combat sports, with some being less well known, such as *ssireum* (also called Korean wrestling), which involves two athletes who use strength and various skills to throw opponents to the ground [12, 13]. Taekwondo is the national martial art of Korea and is divided into two categories: *gyorugi* and *poomsae*. *Gyorugi* is well-known because of the Olympics and international competitions, while *poomsae* is a combination of offensive and defensive skills involving the whole body as well as mental concentration and physical discipline [14]. The sports have different playing styles, requiring different physical characteristics among athletes [15, 16], although even in the same sport, physical characteristics, such as weight, differ and are categorized into weight categories [13, 17-19]. Somatotypes are defined by the physical characteristics of the body. Heath and Carter determined somatotypes by measuring body size, bone width, and skin thickness and subdivided these characteristics into 13 somatotypes [20-22]. The somatotypes of athletes are used to determine body requirements for different sports, including combat sports. By observing the somatotypes of combat sports athletes, the effects of exercise style can be determined to establish how somatotypes are characteristic of different types of sports [15, 16]. A great deal of research has been done to understand the physical characteristics of athletes; however, comparisons of athlete somatotype and body weight among combat sport athletes are limited.

The purpose of study was the somatotype of Korean combat sport athletes based on body weight divisions and physical characteristics in relations the practice of training and sport rehabilitation.

Ssireum (also called *Korean wrestling*) – involves two athletes who use strength and various skills to throw opponents to the ground.

Taekwondo (TKD) – is the national martial art of Korea and is divided into two categories: gyorugi and poomsae.

Gyorugi (Gyo) – or sparring, is the competitive application of techniques in the competition ring. Points are gained by hitting their opponent's body pad or headgear accurately and powerfully, and given away by cheating or unsportsmanlike conduct [38].

Poomsae (Poo) – is a combination of offensive and defensive skills involving the whole body as well as mental concentration and physical discipline.

MATERIAL AND METHODS

Participants

Participants in this study included elite athletes: 40 judo, 32 *ssireum*, 31 taekwondo (*gyorugi*), 20 taekwondo (*poomsae*), 23 boxing, and 13 wrestling. The 159 athletes were volunteers with no physical or psychological conditions who provided written and informed consent to participate in the study. The general characteristics of the athletes studied include age, height, body mass and BMI as well as information on sporting activity (Table 1).

The protocol for the study was approved by the Committee of Ethics in Research of the University of Yong In in accordance with the terms of Resolution 5-1-20. Furthermore, all volunteers provided informed consent for participation in the present study.

Study design

Data were collected from questionnaires and individual, in-depth interviews lasting 20 to 30 minutes [23]. Participants wore only shorts during measurement taking, which was performed by a single research. Before measurement sessions, all participants rested for 30 minutes.

Athletes have been divided into four categories: light weight (–55 to –74 kg), middle weight (–75 to –94 kg), heavy weight (–95 to –114 kg), and superheavy weight (+115 kg). Somatotypes were classified as ectomorphic, mesomorphic, endomorphic, and central types, according to Heath and Carter's modified somatotype method [20-22].

Table 1. General characteristics of Korean combat sport athletes (data were presented as the mean and standard error).

Variable	Judo (n = 40)		Ssireum (n = 32)	Taekwondo *(gyorugi) (poomsae)* (n = 31) (n = 20)		Boxing (n = 23)	Wrestling (n = 13)
Age (yr)		20.6 ±0.2	21.3 ±0.5	19.6 ±0.2	19.8 ±0.3	19.3 ±0.3	19.5 ±0.4
Height (cm)		175.5 ±1.2	178.2 ±1.0	180.5 ±1.0*	174.0 ±1.1$^{\dagger\#}$	173.2 ±1.0$^{\dagger\#}$	174.0 ±1.3$^{\dagger\#}$
Weight (kg)		85.9 ±3.0	96.9 ±3.6*	72.5 ±1.7*†	68.5 ±1.3*†	70.2 ±2.4*†	**83.0 ±4.2$^{\dagger\#\ddagger\S}$**
BMI (kg/cm^2)		27.6 ±0.7	30.3 ±0.9*	22.2 ±0.4*†	22.6 ±0.4*†	23.3 ±0.6*†	**27.4 ±1.2$^{\#\ddagger\S}$**
Career (yr)		9.7 ±0.39	9.4 ±0.6	7.8 ±0.3	10.3 ±0.8	5.6± 0.5	6.5 ±0.9
TT (h/day)		5.2 ±0.2	5.8 ±0.8	4.4 ±0.2	2.9 ±0.1	5.1± 0.3	4.2 ±0.4
TT (h/week) 29.1 ±1.2		34.5 ±4.8	22.0 ±1.0	15.3 ±0.6	30.1± 1.9	23.5 ±2.3	

BMI body mass index; **TT** training time; *†#‡§: p < 0.05.

The girths of the upper arms and the thickest part of the calves were then determined with a tape-line. The breadths of the biepicondylar humerus and biepicondylar femur were measured with a large anthropometer. Finally, the triceps brachii, subscapular, suprailiac, and calf skinfold thicknesses were determined with a medical skinfold caliper (Jamar, Anaheim, CA, USA).

Measurement results were then interpreted with the modified somatotype method [13, 17, 18, 20-22]. The somatotypes were classified as endomorphic, mesomorphic, ectomorphic, and balanced types. They were further broken into 13 subcategories: balanced endomorph (**Ben**, the endomorphic component is dominant, and the values of the mesomorphic and ectomorphic components do not differ by more than 0.5); mesomorphic endomorph (**Men**, the endomorphic component is dominant, and the value of the mesomorphic component is higher than that of the ectomorphic component); mesomorph-endomorph (**M-En**, the values for the mesomorphic and endomorphic components do not differ by more than 0.5, and the value of the ectomorphic component is lower than the other values); endomorphic mesomorph (**EnM**, the mesomorphic component is dominant, and the endomorphic component is higher than the ectomorphic component); balanced mesomorph (**BM**, the mesomorphic component is dominant, and the values of the endomorphic and ectomorphic components do not differ by more than 0.5); ectomorphic mesomorph (**EcM**, the mesomorphic component is dominant, and the ectomorphic component is higher than the endomorphic component); mesomorphectomorph (**M-Ec**, the values of the mesomorphic and ectomorphic components do not differ by more than 0.5, and the value for the endomorphic component is lower than that of the other values); mesomorphic ectomorph (**MEc**, the ectomorphic component is dominant, and the mesomorphic component is higher than the endomorphic component); balanced ectomorph (**BEc**, the ectomorphic component is dominant, and the values for the endomorphic and mesomorphic components do not differ by more than 0.5); endomorphic ectomorph (**EnEc**, the ectomorphic component is dominant, and the endomorphic component is higher than the mesomorphic component); endomorph-ectomorph (**En-Ec**, the values for the endomorphic and ectomorphic components do not differ by more than 0.5, and the value for the mesomorphic component is lower than that of the other values); ectomorphic endomorph (**EcEn**, the endomorphic component is dominant, and the ectomorphic component is higher than the mesomorphic component); and central type (**C**, the values do not differ by 1 in any of the components) [13, 17, 18, 20-22]. The formulas for the Heath-Carter method are as follows:

Endomorphic component = −0.7182 + 0.1451 × ∑SF − 0.00068 × ∑SF^2 + 0.0000014 × ∑SF^3, where:

∑SF = (sum of the triceps brachii, subscapular, and suprailiac skinfold thickness) × [170.18/height (cm)].

Mesomorphic component = 0.858 × breadth of biepicondylar humerus + 0.601 × breadth of biepicondylar femur + 0.188 × modified girth of upper arm + 0.161 × modified girth of calf – height × 0.131 + 4.5: where the modified value is [value – (1/10 of the skinfold thickness of the part)].

The ectomorphic component is calculated as the difference according to the value of the height weight ratio (HWR) (HWR = height/$\sqrt[3]{\text{weight}}$). If HWR −40.75, then ectomorphic component = 0.732 × HWR - 28.58. If 38.25 <HWR <40.75, then ectomorphic component = 0.463 × HWR −17.63. If HWR −38.25, then ectomorphic component = 0.1. The formulas marked on the somatotype chart are as follows [20-22]:

X = ectomorphic component − endomorphic component

Y = 2 × mesomorphic component − (endomorphic component + ectomorphic component)

Statistical analysis

All data were presented as the mean and standard error (±). Statistical analyses were conducted using PASW software (version 18.0) to calculate averages and standard deviations. The significance level was set to α = 0.05 when performing a student t-test. Correlations between weight and somatotype components among athletes were determined using a Pearson correlation coefficient test.

RESULTS

Most of the combat sports athletes were mesomorph dominant, except for taekwondo athletes, for which *gyorugi* athletes were ectomorph dominant, and *poomsae* athletes were evenly distributed among all somatotypes. Subdividing the judo somatotypes resulted in 20 endomorphic mesomorphs, 12 balanced mesomorphs, five ectomorphic mesomorphs, two mesomorph–ectomorphs, and one mesomorph–endomorph. *Ssireum* athletes included 23 endomorphic mesomorphs, six mesomorph–endomorphs, and one mesomorphic endomorph (Table 2).

The *gyorugi* athletes included seven mesomorph–ectomorphs, five balanced ectomorphs, four mesomorphic ectomorphs, four endomorphic

Table 2. Somatotypes (and subcategories) of Korean combat sport athletes (mean and standard error).

Variable	Judo (n = 40)	Ssireum (n = 32)	Taekwondo *(gyorugi) (poomsae)* (n = 31) (n = 20)		Boxing (n = 23)	Wrestling (n = 13)
			Somatotypes:			
Endo (%)	-	2 (6.2)	2 (6.5)	2 (10)	1 (4.3)	-
Meso (%)	40 (100)	30 (93.8)	8 (25.8)	7 (35)	16(69.6)	12 (92.3)
Ecto (%)	-	-	18 (58.1)	8 (40)	4 (17.4)	1 (7.7)
Central(%)	-	-	3 (9.7)	3 (15)	2 (8.7)	-
Endo C.	2.3 ±0.2	**4.5** ±0.3*	**2.2** ±0.1†	**2.4** ±0.2†	**2.3** ±0.2†	**2.7** ±0.3†
Meso C.	5.0 ±0.2	**6.3** ±0.2*	**2.7** ±0.2*†	**2.8** ±0.2*†	**3.7** ±0.2*†#‡	**4.9** ±0.3†#‡§
Ecto C.	1.1 ±0.1	**0.7** ±0.1*	**3.3** ±0.2*†	**2.6** ±0.2*†#	**2.3** ±0.2*†#	**1.2** ±0.3#‡§
			13 subcategories			
Types (%)	EnM 20(50.0)	EnM 23 (71.9)	M-Ec 7 (22.6)	BEc 4 (20.0)	M-Ec 5 (21.7)	EnM 8 (61.5)
	BM 12 (30.0)	M-En 6 (18.8)	BEc 6 (19.4)	BM 4 (20.0)	BM 5 (21.7)	BM 3 (23.1)
	EcM 5 (12.5)	Men 2 (6.3)	MEc 4 (12.9)	Central 3 (15.0)	EnM 5 (21.7)	M-Ec 2 (15.4)
	M-Ec 2 (5.0)	BM 1 (3.1)	EnEc 4 (12.9)	M-En 3 (15.0)	M-En 3 (13.0)	
	M-En 1 (2.5)		Cen 3 (9.7)	EnEc 2 (10.0)	MEc 2 (8.7)	
			EcM 2 (6.5)	M-Ec 1 (5.0)	Cen 2 (8.7)	
			EnM 2 (6.5)	MEc 1 (5.0)	EcM 1 (4.3)	
			BEn 1 (3.2)	EnM 1 (5.0)		
			M-En 1(3.2)	BEn 1 (5.0)		
			Men1 (3.2)			

Endo endomorphy; **Meso** mesomorphy; **Ecto** ectomorphy; **Endo C** endomorphic component; **Meso C** mesomorphic component; **Ecto C** ectomorphic component; **BM** balanced mesomorph; **EcM** ectomorphic mesomorph; **M-Ec** mesomorph ectomorph; **EnM** endomorphic mesomorph; **M-En** mesomorph endomorph. *†#‡§: p < 0.05.

ectomorphs, three central types, two endomorphic mesomorphs, two ectomorphic mesomorphs, two balanced endomorphs, one mesomorphic endomorph, and one mesomorph–endomorph. *Poomsae* athletes included in four balanced ectomorphs, four balanced mesomorphs, three central types, three mesomorph–endomorphs, two endomorphic ectomorphs, one mesomorph–ectomorphs, one mesomorphic ectomorph, one endomorphic mesomorph, and one balanced endomorph (Table 2).

The boxing athletes' somatotypes included five balanced mesomorphs, five endomorphic mesomorphs, five mesomorph–ectomorphs, three mesomorph–endomorphs, two mesomorphic ectomorphs, two central types, and one ectomorphic mesomorph. The wrestling athletes included eight endomorphic mesomorphs, three balanced mesomorphs, and two mesomorph–ectomorphs (Table 2).

Ssireum athletes have higher values for endomorphic and mesomorphic components and lower values for ectomorphic components compared to other athletes. Somatotype component value for judo and wrestling athletes were similar. *Gyorugi* athletes had higher values for ectomorphic

Table 3. Somatotype characteristics in Korean combat sports athletes according to weight divisions.

Weight divisions	Variable	Judo (n = 40)	Ssireum (n = 32)	Taekwondo *(gyorugi)* (n = 31)	Taekwondo *(poomsae)* (n = 20)	Boxing (n = 23)	Wrestling (n = 13)
Light – weight (-55 to -74kg)	Number	14	1	19	17	17	4
	Height (cm)	168.8±1.1	171.0	**177.9±1.1**‡	**173.8±1.2**‡€	**171.4±1.0**€	**171.3±1.7**€
	Weight (kg)	68.0±1.2	70.4	66.7±1.2	67.0±1.1	64.8±1.4	64.7±3.5
	BMI (kg/cm^2)	23.9±0.3	24.1	**21.1±0.3**‡	**22.1±0.3**‡€	**22.1±0.4**‡	**22.1±0.8**‡
	Endo C.	1.4±0.1	4.7‡	**2.2±0.1**‡§	**2.2±0.1**‡§	**2.0±0.1**‡§	**1.6±0.3**§
	Meso C.	4.1±0.2	4.7	**2.6±0.2**‡	**2.7±1.9**‡§	**3.4±0.2**‡€£	**3.6±0.3**
	Ecto C.	1.7±0.1	1.7	**3.6±0.2**‡	**2.8±0.2**‡€	**2.7±0.2**‡€	**2.7±0.3**‡
Middle – weight (-75 to -94kg)	Number	13	21	11	3	5	6
	Height (cm)	**176.2±1.4***	176.0±0.8	**184.5±1.1***‡§	**174.7±2.7**€	**178.8±1.4***€	**174.7±1.9**€
	Weight (kg)	**82.0**±1.2*	**85.8±1.3***	**80.2±1.5***§	**77.4±1.4***§	**82.2±2.0***	**85.9±1.8***€£
	BMI (kg/cm^2)	**26.2**±0.3*	**27.7±0.3***‡	**23.6±0.4***‡§	**25.4±1.2***§	**25.7±0.5***§€	**28.2±0.6***‡€£¥
	Endo C.	**1.9**±0.1*	**3.6±0.2**‡	**2.0±0.2**§	**3.7±0.2***‡€	**3.0±0.3***‡€	**2.8±0.4**€
	Meso C.	**5.0**±0.2*	**5.9±0.2**‡	**2.7±0.2**‡§	**3.5±0.5**‡§	**4.2±0.2***‡§€	**5.3±0.3***€£¥
	Ecto C.	**1.2**±0.1*	0.9±0.1	**2.9±0.2***‡§	**1.5±0.5**€	**1.6±0.2***§€	**0.7±0.2***€¥
Heavy – weight (-95 to -114kg)	Number	10	5	1	-	1	3
	Height (cm)	**180.0**±1.8*	**182.0±1.3***†	187.0	-	176.0	176.3±3.2
	Weight (kg)	**102.2**±1.6*†	**109.2±2.7***†‡	98.2*†	-	101.0*†	**101.8±4.1***†
	BMI (kg/cm^2)	**31.7**±1.1*†	**33.0±0.8***†	28.1*†	-	32.6*†	**32.8±1.8***†
	Endo C.	**3.2**±0.3*†	**5.8±0.4**†‡	4.3*†	-	5.1*†	**3.7±0.5***§
	Meso C.	**5.9**±0.3*†	6.6±0.5	3.0‡	-	5.5*†	**5.9±0.6***
	Ecto C.	**0.5**±0.2*†	**0.2±0.1***†	**1.1***†§	-	0.1*†	**0.3±0.2***
Super heavy – weight (+115kg)	Number	3	5	-	-	-	-
	Height (cm)	**189.0**±1.5*†#	184.6±3.5	-	-	-	-
	Weight (kg)	**132.2**±1.6*†#	**136.3±2.9***†#	-	-	-	-
	BMI (kg/cm^2)	**37.0**±1.0*†#	**40.2±1.8***†#	-	-	-	-
	Endo C.	**5.0**±0.5*†#	**7.2±1.0**†	-	-	-	-
	Meso C.	**6.3**±0.5*†	**8.2±0.5**†‡	-	-	-	-
	Ecto C.	**0.1**±0.0*†#	**0.1±0.0***†	-	-	-	-

BMI body mass index; **Endo C** endomorphic component; **Meso C** mesomorphic component; **Ecto C** ectomorphic component. Each category: *†#: p<0.05; each sports: ‡§€£¥: p<0.05

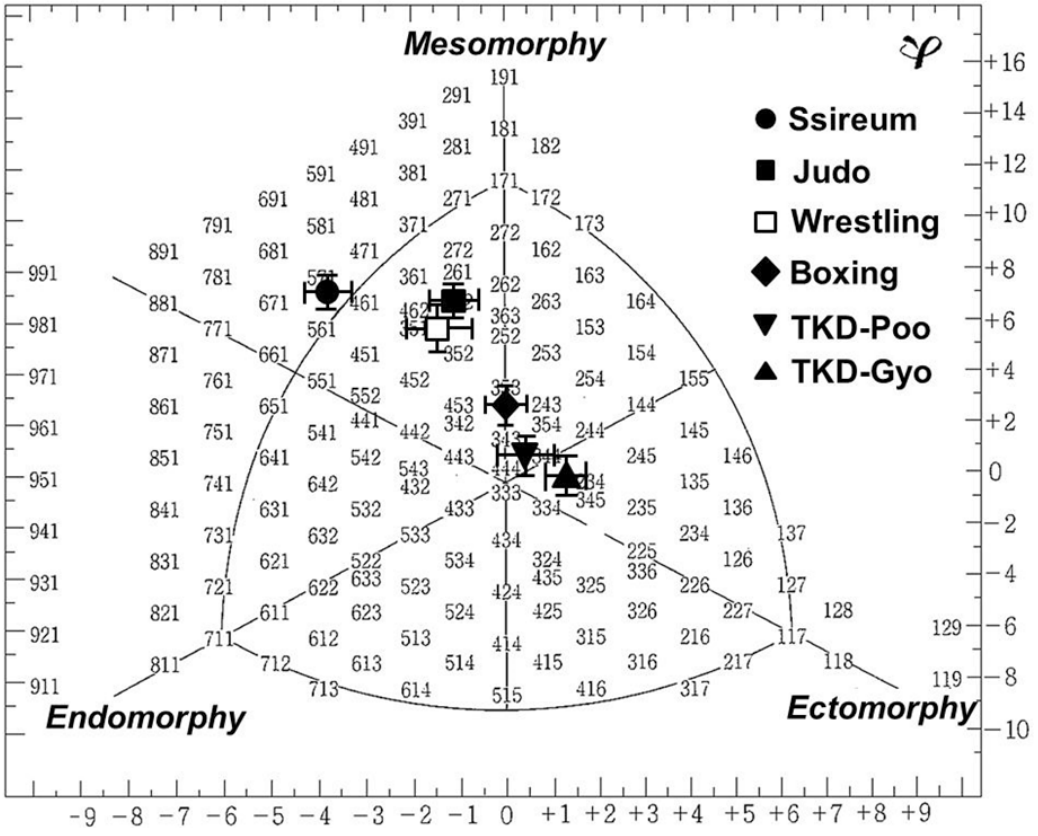

Figure 1. Differences in somatochart among the Korean combat sport athletes.

components compared to other athletes and were taller. Values of all components among the *poomsae* athletes were balanced. Boxing athletes had the same values for endomorphic and ectomorphic components and had higher mesomorphic component values.

Differences in each sport were more significant in the lower- and middle-weight categories compared to heavy- and super-heavy-weight categories (Table 3).

Figure 1 provides a somatotype chart that depicts the body characteristics of athletes in each sport. Differences among somatotype characteristics between each athlete were similar for the four weight categories (Figure 2), and all sports had common differences for higher weight categories, which contained athletes with more endomorphic and mesomorphic components but lower ectomorphic components compared to lower weight groups (Table 3). The somatotype chart shows the classifications of somatotype with points shifting left and upwards for the higher weight categories of all sports (Figure 2).

Correlations between endomorphic components and body weight were significant for all athletes except for *gyorugi* athletes ($p<0.01$; Table 4 and Figure 3). Correlations between mesomorphic components and body weight were significant for judo, *ssireum*, boxing, and wrestling athletes ($p<0.01$), but taekwondo (*gyorugi* and *poomsae*) athletes showed no correlation (Figure 4 and Table 4). Correlation between ectomorphic components and body weight were negative for judo, *ssireum*, *gyorugi*, boxing, and wrestling athletes ($p<0.01$) and negative for *poomsae* athletes ($p<0.05$; Table 4 and Figure 5).

DISCUSSION

It is impossible to define standardized somatotype characteristics, as there are differences according to sport types. Nevertheless, somatotype analysis is very important and closely related to understanding the sport performance and injury mechanisms of each type of combat sports [13, 17, 18]. Somatotypes for different combat sports were compared to athlete body weight, and the results revealed that *ssireum* athletes had the highest levels of mesomorphic and endomorphic

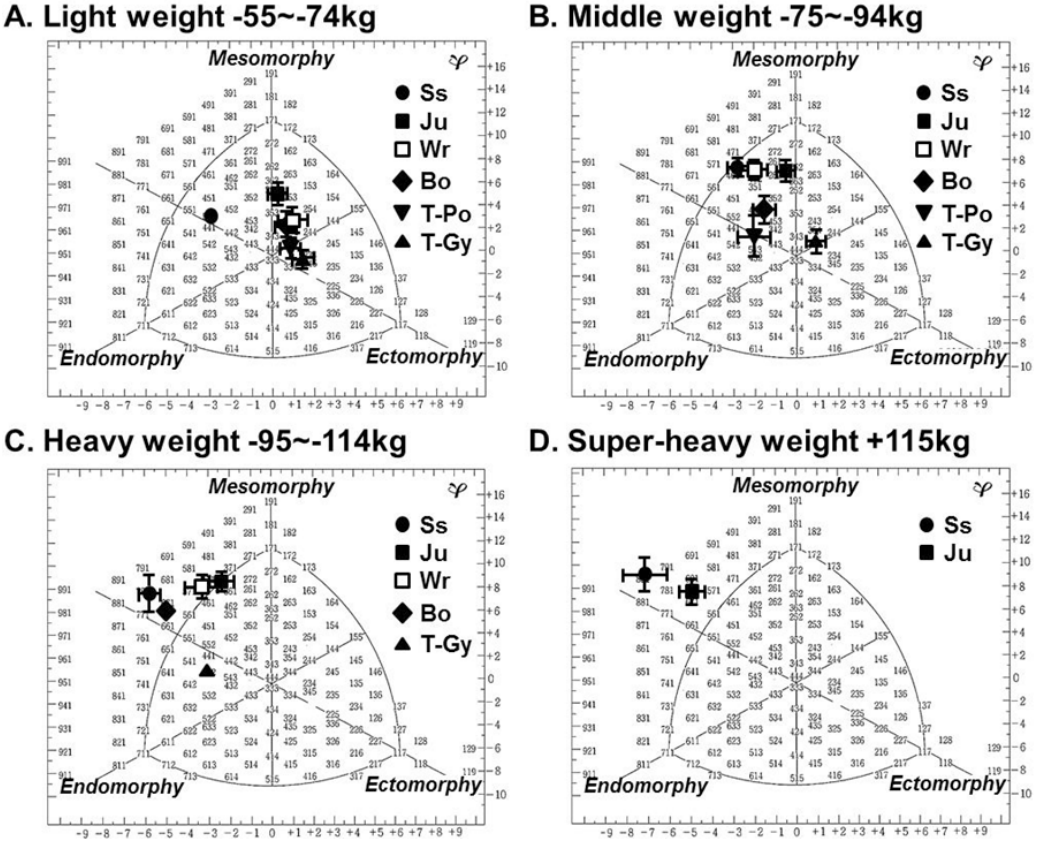

Figure 2. Differences in somatochart among the Korean combat sport athletes based on weight divisions (all data were presented as the mean and ±; athletes: **Ss** *ssireum*; **Ju** judo; **Wr** wrestling; **Bo** boxing; **T-Po** taekwondo *poomsae*; **T-Gy** taekwondo *gyorugi*).

components. Judo athletes also had high mesomorphic values but had lower endomorphic and ectomorphic values, which was similar to all the other athlete groups except for *ssireum* athletes. The somatotype of wrestling athletes was similar to judo athletes, and boxing athletes had mesomorphic dominant body types with balanced components of the other somatotypes. These athletes did have lower mesomorphic component values than judo, *ssireum*, and wrestling athletes. *Gyorugi* athletes had higher ectomorphic values than other athletes and were taller. *Poomsae* athletes had balanced values of all components. All combat sports revealed more significant differences in higher weight divisions, which contained athletes with higher endomorphic and mesomorphic component values and lower ectomorphic component values than lower weight groups.

Each sport required different somatotypes based on specific fighting styles. *Ssireum*, judo, and wrestling required more powerful muscle strength than other sports, while taekwondo and boxing required more power and agility to avoid opponent attacks and allow for quicker hits. *Ssireum* athletes had higher endomorphic components because these athletes use strength to throw opponents to the ground; thus, heavier athletes had the advantage in *ssireum* [24]. Additionally, the fighting time of *ssireum* is the shortest at only one minute; comparatively, judo matches consist of five minute periods and three minutes of additional time, called the golden score [25], *gyorugi* matches consists of three rounds of two minutes each [7], and boxing matches consist of three rounds of three minutes each [26, 27].

Additionally, other sports involve continuous movement until the end of the game to avoid attacks and hold opponents [28-30], but the starting position in *ssireum* involves holding onto a mutual satba (a cloth sash tied around the waist and thigh). Thus, ssireum athletes require more muscular strength than aerobic fitness. As a result, *ssireum* athletes have higher mesomorphic and endomorphic component values compared to other athletes. *Gyorugi* athletes are ectomorph

Table 4. Correlation between weight and somatotype components of each combat sports athletes.

Variable	Judo	Ssireum	Taekwondo (gyorugi)	Taekwondo (poomsae)	Boxing	Wrestling
Endo C & weight	0.892**	0.770**	0.283	0.648**	0.761**	0.821**
Meso C & weight	0.674**	0.700**	0.119	0.392	0.620**	0.738**
Ecto C & weight	-0.765**	-0.754**	-0.714**	-0.519*	-0.821**	-0.905**

* p<0.05, **p<0.01

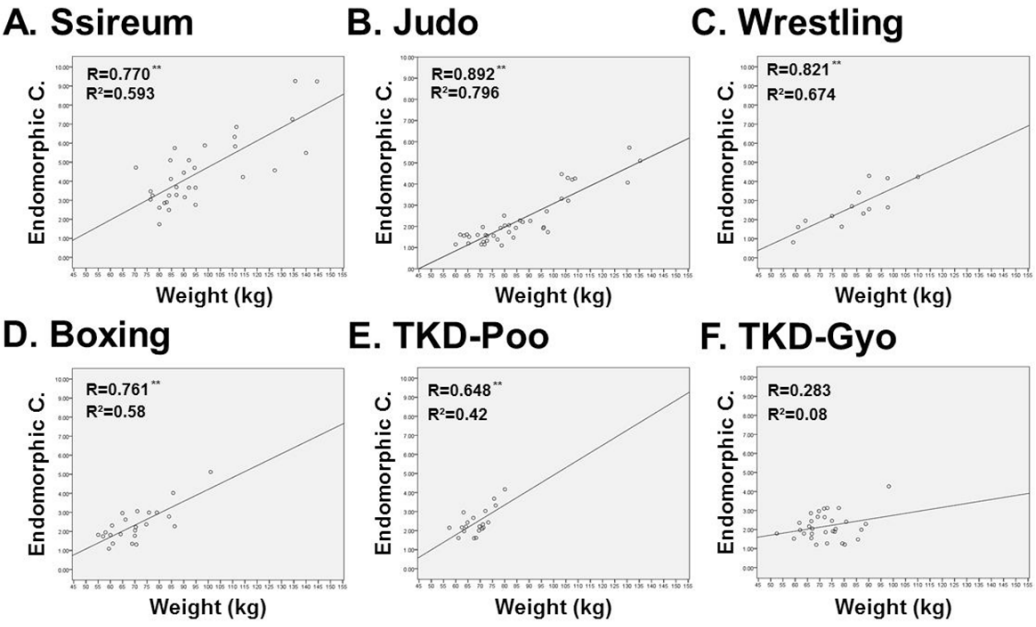

Figure 3. Correlation between weight and endomorphic components of each combat sports (athletes: **TKD-Poo** taekwondo *poomsae*; **TKD-Gyo** taekwondo *gyorugi*); ** p<0.01.

dominant, meaning body type is characterized by length and thinness, and these athletes were also taller than other athletes in the same weight classes. This is because *gyorugi* involves avoiding opponent attacks, quick kicking, and continuous movement until the end of the match, which requires speed and height. This is similar to boxing athletes, among whom mesomorphic body types are more common than among *gyorugi* athletes, while *poomsae* athletes were best suited to a different fighting style [15, 16].

Similar results have been found in research on karate, which is similar to taekwondo. Karate is also divide into two types: *kata* and *kumite*. *Kata* is similar *poomsae*, and *kumite* is similar to *gyorugi*; thus, *kata* athletes are more endomorphic than *kumite* athletes, and *kumite* athletes are more ectomorphic than kata athletes [31-33].

According to the data obtained in this study, somatotype correlates significantly with body weight, except for endomorphic components found among *gyorugi* athlete and mesomorphic components among taekwondo athletes. Correlations between endomorphic components and body weight were significant for all athletes except for *gyorugi* athletes. Correlations between mesomorphic components and body weight were significant among judo, *ssireum*, boxing, and wrestling athletes but did not exist among taekwondo athletes. Correlations between ectomorphic components and body weight were significantly negative among judo, *ssireum*, *gyorugi*, boxing, and wrestling athletes and negative among *poomsae* athletes. Almost all combat sport athletes have mesomorphic body types except for taekwondo athletes, and the somatotype of athletes is influenced by the fighting style of each sports and body weight. However, further systematic and scientific studies in

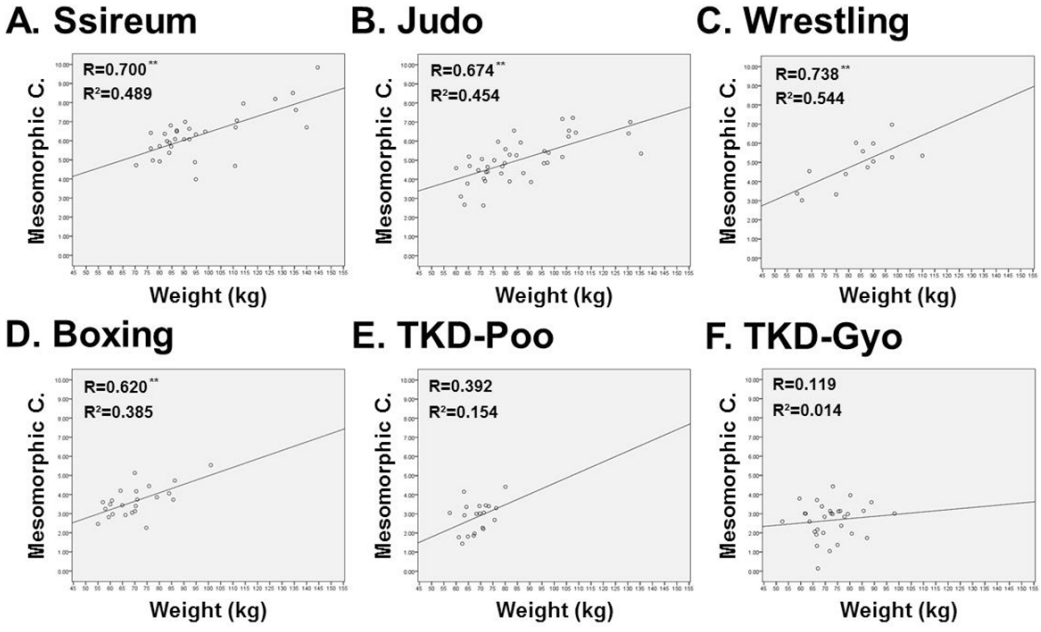

Figure 4. Correlation between weight and mesomorphic components of each combat sports. (athletes: **TKD-Poo** taekwondo *poomsae*; **TKD-Gyo** taekwondo *gyorugi*); ** p<0.01.

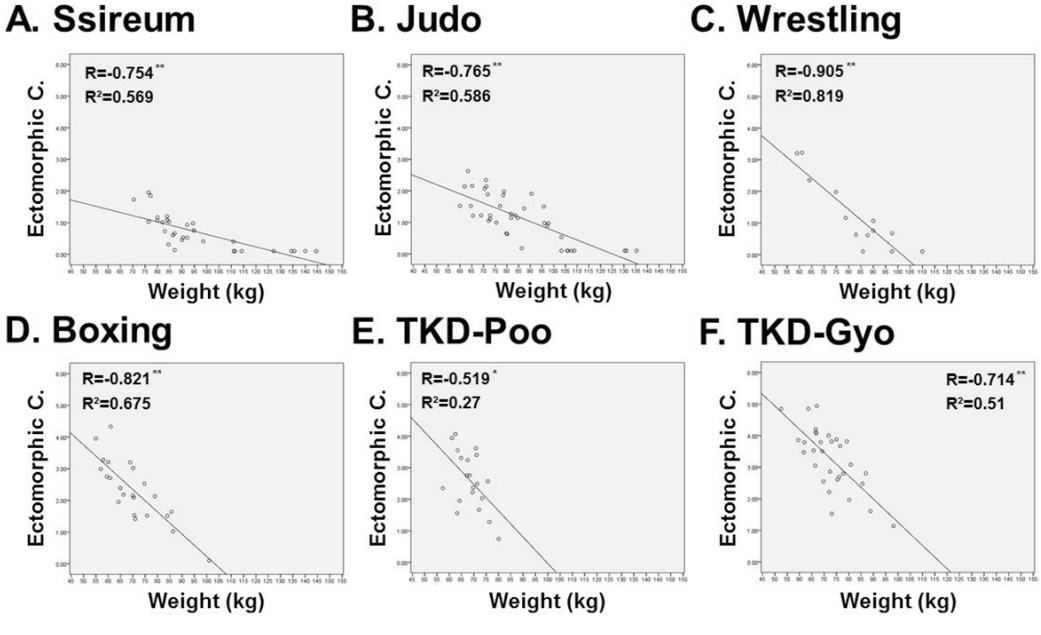

Figure 5. Correlation between weight and ectomorphic components of each combat sports (athlete: **TKD-Poo** taekwondo *poomsae*; **TKD-Gyo** taekwondo *gyorugi*); *p<0.05, ** p<0.01.

the area of sports science are needed to corroborate the pathologic mechanism of sports injury [34-37].

CONCLUSIONS

This study compared the somatotypes of athletes from different combat sports to determine correlations between somatotype and body weight. Almost all combat sport athletes were mesomorphic, except for taekwondo athletes. Taekwondo *gyorugi* athletes were ectomorph dominant, while *poomsae* athletes were a balanced type. It was found that the somatotype of athletes was influenced by fighting style, and except for endomorphic components among *gyorugi* athletes

and mesomorphic component among taekwondo athletes, all somatotype components of combat sport athletes were significantly correlated to body weight. Therefore, injured or ahead-of-the-game elite combat sports athletes require different rehabilitation and training methods based on sport type and body weight. This study also provides a reference of physical characteristics for elite combat athletes, suggests further studies to assist in proper training for athletes returning from injury, and aids rehabilitation.

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