

Comparison between two generations to verify the morphological changes in female futsal athletes in a period of 10 years

Comparação entre duas gerações para verificar as alterações morfológicas em atletas de futsal feminino em um período de 10 anos

Marcos Roberto Queiroga^{1,3}

<https://orcid.org/0000-0002-9284-976X>

Sandra Aires Ferreira³

<https://orcid.org/0000-0003-4491-2485>

Timothy Gustavo Cavazzotto³

<https://orcid.org/0000-0001-9813-6149>

Bruno Sergio Portela¹

<https://orcid.org/0000-0002-8751-9811>

Marcus Peikriszwili Tartaruga¹

<https://orcid.org/0000-0003-1173-2816>

Matheus Amarante do Nascimento^{2,3}

<https://orcid.org/0000-0002-4677-8956>

Danilo Fernandes da Silva¹

<https://orcid.org/0000-0002-4170-1079>

Abstract – The aim was to compare two generations to verify the morphological changes in female futsal athletes. Age, years of playing, anthropometry measurements, percentage body fat and somatotype were compared between professional athletes in 2001 (n=112) and 2011 (n=115). The 2011 group revealed a significant longer practice time (9.0±4.3 vs. 5.7±3.5 years; p<0.001), higher thigh skinfold (26.1±8.5 vs. 22.5±6.7 mm; p<0.001), circumference of tensed forearm (27.4±2.1 vs. 26.7±2.1 cm; p=0.007), mesomorphy (4.1 vs. 3.3; p=0.001) and lower supraspinal skinfold (14.0±5.0 vs. 19.1±7.4 mm; p<0.001), trunk/extremity relationship (0.8±0.3 vs. 1.1±0.1; p<0.001) and endomorphy (4.5 vs. 5.0; p=0.009) than those of the 2001 athletes. Comparison in playing positions revealed that the 2011 goalkeepers (9.5±5.0 vs. 6.3±3.4 years; p=0.027), wings (9.0±4.3 vs. 5.4±3.2 years; p=0.001) and fixed (8.4±4.3 vs. 6.9±4.5 years; p=0.001) practiced more time than the 2001 athletes, whereas the somatotype profile of goalkeepers (4.6±1.0 vs. 3.4±1.1; p=0.001), wings (3.9±0.8 vs. 3.0±0.9; p=0.001), pivots (3.8±1.0 vs. 3.4±1.0; p=0.028) and fixed (4.3±0.9 vs. 3.7±1.0; p=0.036) registered a higher mesomorphy rate than that of the 2001 athletes, respectively. We may conclude that the 2011 group showed a significant increase in practicing time, coupled to higher mesomorphy and lower endomorphy rates than those experienced by the 2001 athletes.

Key words: Anthropometry; Exercise; Soccer; Sports medicine; Women.

Resumo – O objetivo foi comparar duas gerações para verificar as alterações morfológicas em atletas de futsal feminino. Idade, tempo de treino, medidas antropométricas, percentual de gordura e somatotipo foram comparadas entre atletas profissionais de 2001 (n=112) e 2011 (n=115). A geração de 2011 demonstrou significativamente maior tempo de prática (9,0±4,3 vs 5,7±3,5 anos; p<0,001), espessura da dobra cutânea da coxa (26,1±8,5 vs 22,5±6,7 mm; p<0,001), circunferência de braço contraído (27,4±2,1 vs 26,7±2,1 cm; p=0,007), mesomorfia (4,1 vs 3,3; p=0,001) e menor espessura da dobra cutânea supraespinhal (14,0±5,0 vs 19,1±7,4 mm; p<0,001), relação tronco/extremidade (0,8±0,3 vs 1,1±0,1; p<0,001) e endomorfia (4,5 vs 5,0; p=0,009) do que as atletas de 2001. A comparação de acordo com a posição em quadra revelou que as goleiras (9,5±5,0 vs 6,3±3,4 anos; p=0,027) alas (9,0±4,3 vs 5,4±3,2 anos; p=0,001) e fixos (8,4±4,3 vs 6,9±4,5 anos; p=0,001) de 2011, apresentaram maior tempo de prática do que as atletas de 2001, enquanto o perfil somatotípico das goleiras (4,6±1,0 vs 3,4±1,1; p=0,001), alas (3,9±0,8 vs 3,0±0,9; p=0,001), pivôs (3,8±1,0 vs 3,4±1,0; p=0,028) e fixos (4,3±0,9 vs 3,7±1,0; p=0,036) apresentaram maior mesomorfia do que as atletas de 2001, respectivamente. Conclui-se que o grupo de 2011 demonstrou maior tempo de prática e taxas de mesomorfia, além de menor endomorfia comparado às atletas de 2001.

Palavras-chave: Antropometria; Exercício; Futebol; Medicina esportiva; Mulheres.

1 Universidade Estadual do Centro-Oeste. Department of Physical Education. Guarapuava, PR. Brazil.

2 Universidade Estadual do Paraná. Colegiado de Educação Física. Campus Paranavaí. Paranavaí, PR. Brazil.

3 Universidade Estadual de Londrina. Graduate Program in Physical Education UEM-UEL. Londrina, PR. Brazil.

Received: 09 May 2018

Accepted: 12 October 2018

How to cite this article

Queiroga MR, Ferreira SA, Cavazzotto TG, Portela BS, Tartaruga MP, Nascimento MA, Silva DF. Comparison between two generations to verify the morphological changes in female futsal athletes in a period of 10 years. Rev Bras Cineantropom Desempenho Hum 2019, 21:e56970. DOI: <http://dx.doi.org/10.5007/1980-0037.2019v21e56970>.

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INTRODUCTION

Nowadays Futsal is acknowledged and ruled by the Fédération Internationale de Football Association (FIFA) since 1989¹. Over the past 10 years, futsal has been one of the fastest growing indoor sports in the world². Futsal is played between two teams of five players divided into four on-court players and the goalkeeper³. On-court players comprise one pivot (attacker), one fixed (defender) and two wings (left and right), differently of soccer that is played with 11 athletes. Futsal is played on a smaller side (20 × 40 m) over a shorter period (2 × 20 min), albeit with great intensity. Barbero-Alvarez et al.³ demonstrated that futsal involves high intensity sprint activities for a large proportion of the game (22.6% of the movements) compared to soccer or other intermittent sports, and higher percentage body fat may play a negative role on overloading specific motor action within the game⁴. In this way, it seems that greater mesomorphy profile should be privileged compared to endomorphy in futsal players⁴.

Whereas in the past female futsal players were also involved in soccer competitions, at present, most of them are playing futsal only, and high-level clubs contract professional players for competitions⁴. Despite the growing popularity of women's futsal and the increasing number of female players worldwide, there have been few researches on female futsal players⁵, mainly concerning their morphological status⁴.

Anthropometric characteristics and body composition are features underlying excellence in athletic performance. The relationship between success in sports and certain physical standards, particularly low body fat and greater muscle mass, has been shown in several female sport modalities such as lightweight rowers⁶, gymnasts⁷ and modern pentathlon athletes^{8,9}. However, the information regarding anthropometric parameters related to performance is lacking in female futsal players, more specifically in relation to its pattern changes over time (i.e., differences within a period of 10 years), which will be of particular importance for developing this sport⁵.

Information that will add value to develop female futsal players is the somatotype assessment and monitoring, which are particularly important in providing estimates of morphological changes over time, coupled to training process, assessments of performance profile, selection criteria of athletes, and new specific information to coaches to improve practices. Thus, the current study aimed to compare two generations (i.e., 2001 and 2011) to verify the morphological changes in female futsal athletes. In addition, we provided comparison between the generations according to the position/function on the field.

METHOD

Participants

The study was undertaken with athletes from the Women's Futsal Clubs (Special division) in 2001 (2001 group) and in 2011 (2011 group). Since

1992, the competition is a yearly event organized by the Brazilian Futsal Confederation (<http://www.cbfs.com.br>) between ten teams, one from the host city and the other nine champions from other Brazilian states.

Study population consisted of 227 elite female futsal players from top Brazilian clubs. They represented all the athletes who participated of the competitions in 2001 ($n = 112$) and 2011 ($n = 115$). Data of the first study arm were collected during the 2001 X Women's Brazil Futsal Cup in Brasilia, DF, Brazil, when 112 athletes (49.3%) were assessed. On the other hand, information on the second study arm was collected during the 2011 XX Women's Brazil Futsal Cup in Criciuma, SC, Brazil, with 115 athletes (50.7%). No athlete was assessed in both years (i.e., 2001 and 2011). Ten coaches (37.0 ± 8.0 years old) confirmed the tactical function of the athlete on the field and described the technical/tactic evolution of women's futsal during the two years (2001 and 2011) under analysis. Seven out of the 10 coaches interviewed in 2001 headed teams in 2011.

The analysis was approved by the Local Ethics Board on Human Research (Process n. 039/2011) and complies with Resolution 196/96 of the National Health Council of the Brazilian Ministry of Health and the declaration of Helsinki on research involving human beings. All players and coaches were fully informed about the type and purpose of current study and all signed a consent form.

Measures

All anthropometric measurements were taken by the same experienced investigator (2001 and 2011), with the same instruments, on the female athletes wearing no shoes and only light clothing, following standardized procedures¹⁰. Anthropometric measurements were obtained in a private room at approximately the same time of the day, for five days.

Body mass was assessed by a 100 g precision anthropometric scale (Welmy™ São Paulo, Brazil) and height was measured by a 0.1 cm-scale stadiometer fixed in the wall. Body Mass Index (BMI) was calculated as body mass (kg)/height squared (m^2).

Measurements of mid-upper-arm girth and calf girth (cm) were obtained using a non-elastic tape (to the nearest 0.1 cm) (Mabis™ Curitiba, Brazil). The mid-upper-arm girth (cm) was measured with the arm in a tensed position, while calf girth (cm) was measured with the athletes sitting on a chair, with legs on the ground. Biepicondylar humerus and femur breadth were measured to the nearest 0.1 cm with a metal caliper (Somet™ Curitiba, Brazil).

Skinfold thickness (SKF) was measured at six sites (triceps, subscapular, supraspinal, suprailiac, midthigh and medial calf) to the nearest 0.1 mm with a Cescorf caliper (Cescorf™, Porto Alegre, Brazil). Trunk/Extremity skinfold ratio (TER) ($[\text{subscapular} + \text{supraspinale} + \text{suprailiac}] / [\text{triceps} + \text{midthigh} + \text{medial calf}]$) was computed as an indicator of body fatness distribution.

The sum of three skinfold thicknesses (3SKF) (triceps + suprailiac + midthigh) determined body density¹¹. Body fat percentage (%BF) was then

calculated with the equation described by Siri¹². Fat mass (FM) and lean body mass (LBM) were calculated in kg, as follow: $FM = (\%BF/100) \times \text{body mass}$; $LBM = \text{body mass} - FM$. The three somatotype components (i.e., endomorphy, mesomorphy and ectomorphy) were calculated according to the Heath and Carter Anthropometric Somatotyping Method¹³.

All variables were measured twice on the right side of the body. A third measure was taken if a difference greater than 0.2 mm for skinfold thickness, or a 0.5 cm difference for the other variables was recorded. The final score used in the data analysis was the mean of the two scores or the median of three.

Statistical analysis

All analyses were undertaken with Statistical Package for Social Sciences version 15.0 (SPSS Inc., Chicago, IL), at significance level $p < 0.05$. Shapiro-Wilk test ($n \leq 50$) and Komolgorov-Smirnov ($n > 50$) were initially used for the analysis of data distribution. Due to data symmetry, all variables were given in means \pm standard deviation. Anthropometric and somatotype variables were compared at two instances (i.e., 2001 vs. 2011) in all position together (i.e., total sample for each year) and according to each playing position by Student's *t* test for unpaired data.

The Somatotype Attitudinal Distance (SAD), characterized as the spatial distance between any two somatopoints, identifying significant differences from $SAD > 2.0$, demonstrated the somatotype differences between the groups (2001 vs. 2011) in all playing position together and according to each playing position (goalkeeper, pivot, fixed, and wings)¹⁴.

The Effect Size was estimated using bias-corrected Hedges' *g* equation¹⁵. Values between 0.0 - 0.50 were considered small effect size, 0.50 - 0.80 medium effect, and values over 0.80, large effects¹⁶.

RESULTS

Table 1 demonstrates the amount of years involved in the sport, age, anthropometric measurements and SAD of the athletes evaluated in 2001 and 2011. Whereas the 2001 athletes had a shorter practice time than those evaluated in 2011, chronological age did not vary significantly. Further, the 2001 athletes had a greater supraspinale and TER, but a lower thigh SKF and forearm circumference than the 2011 athletes, respectively.

Results from the somatotype profile showed that the 2001 athletes had a higher endomorphy and a lower mesomorphy than those of the 2011 ones. Whereas the 2001 athletes were classified as mesomorphic-endomorphic (5.0-3.3-2.1), the 2011 athletes were classified as mesomorphic-endomorphic (4.5-4.1-2.0) (Table 1; Figure 1). Analyses for other anthropometric variables revealed similar physical characteristics between the two groups. There was no statistical difference for spatial distance (0.5) between the two somatotypes (2001 vs. 2011) when the somatotypes of the teams were compared by SAD.

Table 1. General characteristics of female futsal players in 2001 (n = 112) and 2011 (n = 115)

Variables	Total (n = 227)	2001 (n = 112)	2011 (n = 115)	p Value	Effect Size (95% CI)
Years of playing	7.4 ± 4.2	5.7 ± 3.5	9.0 ± 4.3	<0.001	-0.84 (-0.57 -1.11)
Age (years)	22.0 ± 4.7	22.1 ± 5.4	22.0 ± 3.9	0.894	0.02 (0.28 -0.24)
Body mass (kg)	58.5 ± 7.3	58.4 ± 7.0	58.6 ± 7.6	0.817	-0.03 (0.23 -0.29)
Body height (cm)	161.8 ± 6.4	161.8 ± 6.3	161.8 ± 6.5	0.997	0.00 (0.26 -0.26)
BMI (kg/m ²)	22.3 ± 2.0	22.3 ± 1.9	22.3 ± 2.1	0.753	0.00 (0.26 -0.26)
Triceps (mm)	16.2 ± 4.9	16.2 ± 4.6	16.2 ± 5.2	0.970	0.00 (0.26 -0.26)
Subscapular (mm)	13.5 ± 4.6	14.0 ± 4.8	13.0 ± 4.4	0.101	0.22 (0.48 -0.04)
Suprailiac (mm)	16.5 ± 6.8	16.5 ± 7.0	16.6 ± 6.7	0.871	-0.01 (0.25 -0.27)
Supraspinale (mm)	16.5 ± 6.8	19.1 ± 7.4	14.0 ± 5.0	<0.001	0.81 (1.08 -0.54)
Midthigh (mm)	24.3 ± 7.9	22.5 ± 6.7	26.1 ± 8.5	<0.001	-0.47 (-0.2 -0.73)
Medial calf (mm)	12.9 ± 4.5	12.7 ± 4.5	13.0 ± 4.6	0.652	-0.07 (0.19 -0.33)
Sum of 6SKF (mm)	100.0 ± 25.7	101.0 ± 26.3	98.9 ± 25.1	0.534	0.08 (0.34 -0.18)
TER	1.0 ± 0.3	1.1 ± 0.1	0.8 ± 0.3	<0.001	1.33 (1.62 -1.04)
Body fat (%)	22.4 ± 5.1	22.7 ± 5.1	22.2 ± 5.2	0.445	0.09 (0.36 -0.16)
FM (kg)	13.5 ± 4.5	13.8 ± 4.3	13.2 ± 4.6	0.353	0.13 (0.39 -0.13)
LBM (kg)	45.0 ± 4.3	44.6 ± 4.1	45.4 ± 4.5	0.173	-0.19 (0.08 -0.45)
Humerus width (cm)	6.1 ± 0.3	6.1 ± 0.3	6.1 ± 0.3	0.428	0.00 (0.26 -0.26)
Femur width (cm)	8.8 ± 0.4	8.8 ± 0.4	8.8 ± 0.5	0.923	0.00 (0.26 -0.26)
Biceps girth (tensed) (cm)	27.1 ± 2.1	26.7 ± 2.1	27.4 ± 2.1	0.007	-0.33 (-0.07 -0.59)
Calf girth (cm)	35.1 ± 2.4	34.8 ± 2.7	35.3 ± 2.1	0.139	-0.21 (0.05 -0.47)
Endomorphy	4.7 ± 1.2	5.0 ± 1.3	4.5 ± 1.1	0.009	0.41 (0.68 0.15)
Mesomorphy	3.7 ± 1.0	3.3 ± 1.0	4.1 ± 0.9	0.001	-0.84 (-0.57 -1.11)
Ectomorphy	2.1 ± 0.9	2.1 ± 0.9	2.0 ± 1.0	0.879	0.10 (0.37 -0.16)
Categories	mesomorphic endomorph	Mesomorphic endomorph	mesomorphic- endomorph		
SAD			0.5		

Note. Sum of 6SKF: triceps + subscapular + suprailiac + supraspinale + midthigh + medial calf; TER: Trunk/Extremity skinfold ratio; FM: Fat mass; LBM: lean body mass; SAD: Somatotype Attitudinal Distance - groups 2001 and 2011. Somatotype categories (Carter¹⁷). P < 0.05; data are shown as mean ± SD; 2001 vs 2011 – Student's t test for unpaired data.

Figure 1 registers the distribution of mean somatotypes of futsal female athletes in 2001 and 2011 and shows that most 2001 athletes are concentrated on the left side of the somatochart (endomorph), whereas the 2011 group showed a trend towards the top of the somatochart (mesomorphy).

Table 2 provides a comparative view of years of playing, age, anthropometric measurements and SAD between two groups (e.g., 2001 vs. 2011) of futsal female athletes, according to their tactical function/position on the field, namely, goalkeeper, wings, pivot and fixed.

Although there was no age difference in goalkeepers and outfielders, the 2001 goalkeepers, wings and fixed ($p < 0.05$) had a shorter practice time than the 2011 athletes with the same function. Moreover, the anthropometric variables of the 2001 goalkeepers had a lower tensed forearm circumference but a higher supraspinale SKF thickness and TER than that of the 2011 goalkeepers. The 2001 right and left wings had a higher supraspinale SKF thickness and TER than those of the 2011 wings.

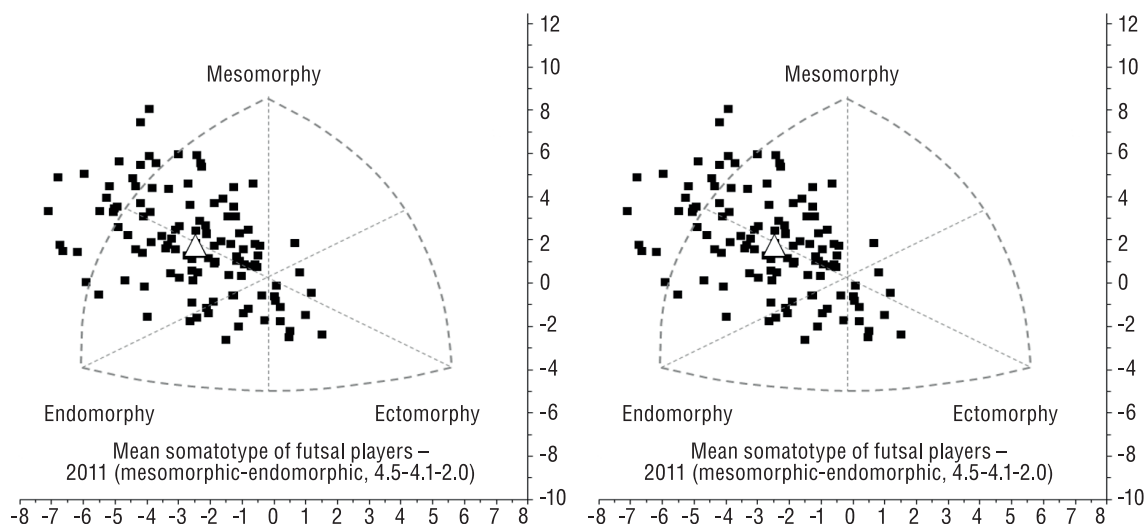


Figure 1. Somatochart with the mean somatotype values of female futsal players in 2001 ($n = 112$) and 2011 ($n = 115$). ■: athletes; ▲: average value. Endomorphy is located on the left, mesomorphy at the top and ectomorphy on the right of the somatochart. Somatotype categories (Carter¹⁷).

The 2001 pivot athletes had a lower thigh SKF thickness but a greater supraspinale SKF thickness than those of the 2011 attackers. On the other hand, the 2001 fixed athletes revealed a higher supraspinale SKF thickness, TER and lower lean mass than those of the 2011 athletes in the same position.

Somatotype results demonstrate that goalkeepers, wings, pivots and fixed in 2001 had a lower mesomorphy than that of the 2011 athletes, although the 2001 wings demonstrated higher endomorphy than the 2011 wings. Although somatotype classification (mesomorphic-endomorphic) failed to evidence any alterations between 2001 and 2011 goalkeepers, a decrease in endomorphy and an increase in mesomorphy was reported for the 2011 group, with a balance between the two factors (endomorph-mesomorphic).

Comparison by SAD of the somatotypes of the two groups of athletes revealed no difference between futsal female athletes due to their tactic function/position on the field. The goalkeepers showed the closest SAD (1.8) with a two-unit difference (Table 2).

Figure 2 presents the effects sizes between the comparison between 2001 and 2011 for the anthropometric variables in each tactic function/position.

DISCUSSION

Results show that although some small changes (e.g., increase in midhigh, tensed biceps girth, and decrease in endomorphy) in female futsal athletes morphological structures occurred in ten years in Brazil, they affected the somatotype classification with improved muscular development (e.g., large increase in mesomorphy). These results were emphasized in the 2001 vs. 2011 comparison according to each playing position (e.g., goalkeepers increased tensed biceps girth, and fixed players increase lean mass). Since

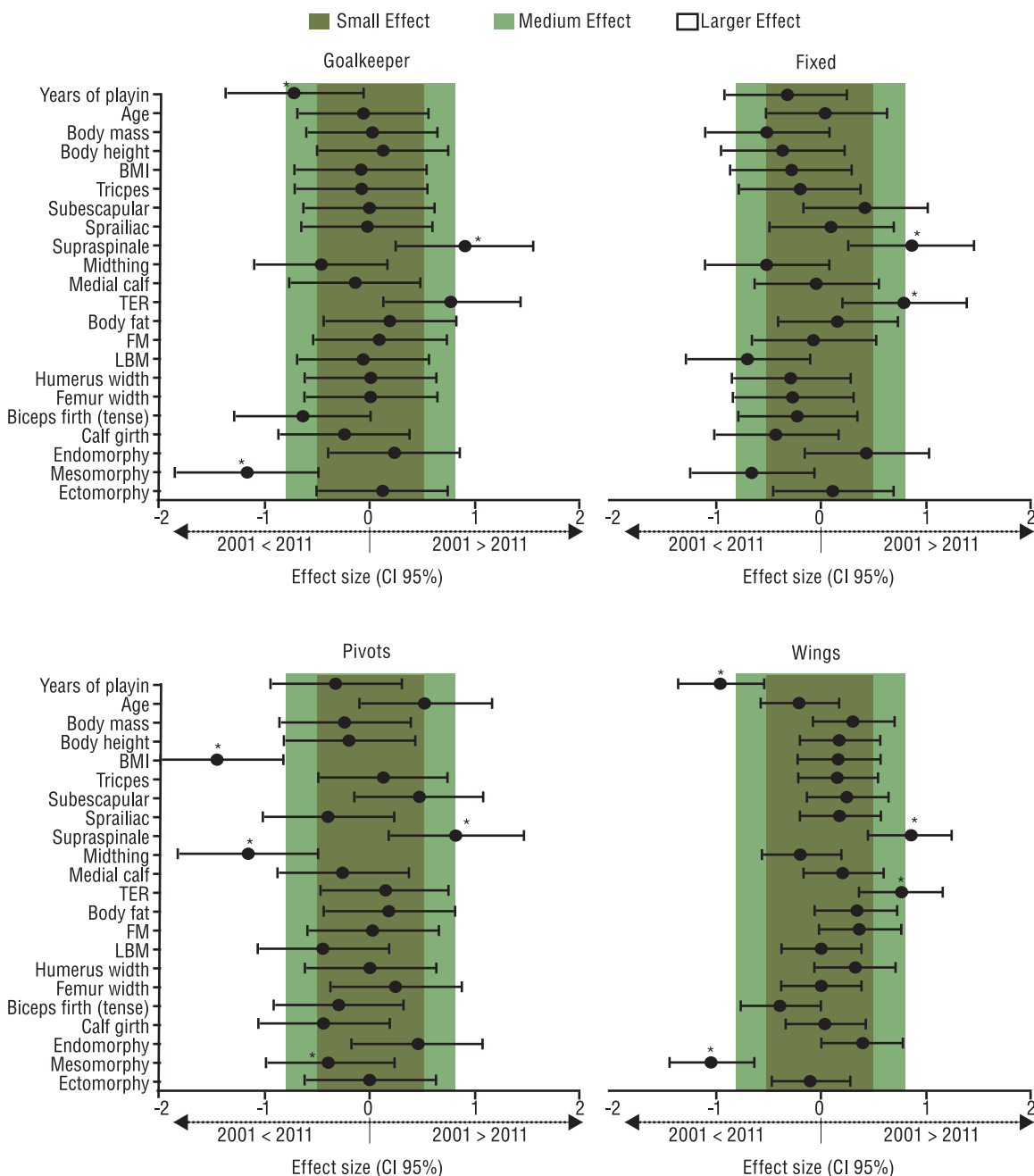


Figure 2. Effect sizes in each tactic function/position for the anthropometric variables^{15,16}
 * p<0,05

no significant differences were recorded between the chronological ages of the two groups, it could be assumed that the level of age maturity of both groups was similar. However, practice time (i.e., “years of playing”) by the 2011 group was longer than that of the 2001 athletes, which is a relevant factor of change between the two generations assessed.

Several 2001 players reported that they started their sports carrier by playing soccer prior to futsal⁴, which may have provided a reduced experience in the latter. However, information given by coaches revealed a significant evolution in the athletes’ technical and tactical performance

Table 2. General characteristic of female futsal players in 2001 (n = 112) and 2011 (n = 115) according to their position

Variables	Goalkeeper (n=39)			Wings (n=102)		
	2001 (n=19)	2011 (n=20)	p value	2001 (n=53)	2011 (n=49)	p value
Years of playing	6.3 ± 3.4	9.5 ± 5.0	0.027	5.4 ± 3.2	9.0 ± 4.3	0.001
Age (years)	22.2 ± 3.9	22.5 ± 4.4	0.827	21.0 ± 5.1	21.9 ± 3.5	0.301
Body mass (kg)	63.9 ± 8.3	63.8 ± 10.4	0.967	56.9 ± 6.8	55.0 ± 5.2	0.118
Body height (cm)	164.5 ± 6.1	163.6 ± 8.5	0.693	161.4 ± 6.9	160.2 ± 6.3	0.367
BMI (kg/m ²)	23.5 ± 2.3	23.7 ± 2.3	0.826	21.8 ± 1.6	21.5 ± 1.8	0.333
Triceps (mm)	19.5 ± 5.0	20.0 ± 6.7	0.796	15.2 ± 4.0	14.6 ± 3.4	0.425
Subscapular (mm)	16.9 ± 6.9	17.0 ± 5.9	0.960	12.9 ± 3.7	12.0 ± 3.3	0.218
Suprailiac (mm)	16.5 ± 7.2	16.7 ± 4.8	0.937	16.2 ± 6.8	15.0 ± 5.7	0.368
Supraspinale (mm)	24.0 ± 7.6	17.8 ± 5.8	0.007	17.3 ± 6.0	12.7 ± 4.5	0.001
Midthigh (mm)	25.2 ± 6.8	29.6 ± 11.1	0.149	22.5 ± 7.4	23.8 ± 6.6	0.364
Medial calf (mm)	15.6 ± 5.4	16.5 ± 6.3	0.643	12.4 ± 4.1	11.6 ± 3.1	0.239
Sum of 6SKF (mm)	117.8 ± 27.4	117.6 ± 32.4	0.983	96.4 ± 23.5	89.6 ± 17.5	0.811
TER	1.1 ± 0.1	0.8 ± 0.3	0.001	1.1 ± 0.1	0.8 ± 0.2	0.001
Body fat (%)	26.2 ± 5.1	25.6 ± 6.5	0.776	21.7 ± 4.9	20.5 ± 3.9	0.180
FM (kg)	17.3 ± 5.0	16.8 ± 6.5	0.759	12.7 ± 3.9	11.4 ± 3.0	0.062
LBM (kg)	46.6 ± 4.5	47.0 ± 6.0	0.792	44.2 ± 4.3	43.6 ± 3.3	0.468
Humerus width (cm)	6.2 ± 0.3	6.2 ± 0.3	0.818	6.1 ± 0.3	6.0 ± 0.3	0.063
Femur width (cm)	9.0 ± 0.4	9.0 ± 0.6	0.848	8.7 ± 0.4	8.7 ± 0.4	0.362
Biceps girth (tensed) (cm)	28.3 ± 1.9	29.7 ± 2.3	0.048	25.9 ± 1.5	26.5 ± 1.6	0.067
Calf girth (cm)	35.5 ± 3.6	36.3 ± 2.6	0.383	34.4 ± 2.9	34.3 ± 1.6	0.778
Endomorphy	5.8 ± 1.3	5.5 ± 1.3	0.440	4.6 ± 1.1	4.2 ± 0.9	0.042
Mesomorphy	3.4 ± 1.0	4.6 ± 1.0	0.001	3.0 ± 0.9	3.9 ± 0.8	0.001
Ectomorphy	1.7 ± 0.8	1.6 ± 0.9	0.689	2.2 ± 0.8	2.3 ± 1.0	0.536
Categories	Mesomorphic- endomorph	Mesomorphic- endomorph		Mesomorphic- endomorph	Mesomorphic- endomorph	
SAD	1.8			1.2		
Variables	Pivots (n=40)			Fixed (n=46)		
	2001 (n=20)	2011 (n=20)	p value	2001 (n=20)	2011 (n=26)	p value
Years of playing	6.9 ± 4.5	8.4 ± 4.3	0.288	6.9 ± 4.5	8.4 ± 4.3	0.001
Age (years)	24.4 ± 7.1	21.3 ± 3.9	0.103	22.5 ± 5.2	22.3 ± 4.3	0.875
Body mass (kg)	57.4 ± 6.4	59.2 ± 7.2	0.390	58.0 ± 4.9	60.9 ± 5.9	0.082
Body height (cm)	160.9 ± 5.5	162.0 ± 5.3	0.508	161.3 ± 5.0	163.3 ± 5.6	0.202
BMI (kg/m ²)	22.2 ± 2.0	25.5 ± 2.4	0.652	22.3 ± 1.8	22.8 ± 1.7	0.335
Triceps (mm)	15.8 ± 5.6	15.2 ± 3.7	0.709	16.1 ± 3.3	17.1 ± 6.0	0.503
Subscapular (mm)	14.0 ± 5.6	11.9 ± 2.9	0.157	14.2 ± 3.2	12.6 ± 4.1	0.141
Suprailiac (mm)	15.6 ± 8.4	19.4 ± 9.6	0.191	18.0 ± 6.1	17.4 ± 6.4	0.718
Supraspinale (mm)	19.4 ± 9.9	13.2 ± 3.6	0.016	19.1 ± 6.1	14.2 ± 5.1	0.005
Midthigh (mm)	19.5 ± 5.4	26.5 ± 6.3	0.001	23.1 ± 4.7	27.4 ± 10.0	0.061
Medial calf (mm)	10.7 ± 3.9	11.8 ± 4.3	0.090	12.9 ± 3.9	13.1 ± 4.2	0.881
Sum of 6SKF (mm)	95.0 ± 32.1	99.3 ± 18.8	0.161	103.4 ± 20.1	101.7 ± 27.6	0.570
TER	1.2 ± 0.2	0.9 ± 0.4	0.001	1.2 ± 0.1	0.8 ± 0.2	0.001
Body fat (%)	21.8 ± 5.8	21.8 ± 3.8	0.958	23.0 ± 3.7	22.9 ± 5.8	0.965

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Variables	Pivots (n=40)			Fixed (n=46)		
	2001 (n=20)	2011 (n=20)	p value	2001 (n=20)	2011 (n=26)	p value
FM (kg)	13.2 ± 4.3	13.1 ± 3.4	0.907	13.8 ± 3.1	14.1 ± 4.6	0.813
LBM (kg)	44.2 ± 3.4	46.1 ± 4.7	0.157	44.2 ± 2.9	46.8 ± 4.1	0.018
Humerus width (cm)	6.0 ± 0.2	6.0 ± 0.3	0.857	6.1 ± 0.2	6.2 ± 0.4	0.376
Femur width (cm)	8.9 ± 0.4	8.8 ± 0.4	0.969	8.9 ± 0.3	9.0 ± 0.4	0.155
Biceps girth (tensed) (cm)	26.7 ± 1.8	27.3 ± 2.0	0.322	27.2 ± 2.7	27.7 ± 1.7	0.477
Calf girth (cm)	34.7 ± 1.6	35.6 ± 2.3	0.150	35.4 ± 2.0	36.2 ± 1.7	0.153
Endomorphy	4.9 ± 1.7	4.3 ± 0.8	0.163	5.0 ± 1.0	4.5 ± 1.2	0.148
Mesomorphy	3.4 ± 1.0	3.8 ± 1.0	0.036	3.7 ± 0.9	4.3 ± 0.9	0.028
Ectomorphy	2.0 ± 1.0	2.0 ± 1.0	0.909	2.0 ± 0.9	1.9 ± 0.8	0.600
Categories	Mesomorphic- endomorph	Mesomorphic- endomorph		Mesomorphic- endomorph	Mesomorphic- endomorph	
SAD	0.8			0.9		

Note. Sum of 6SKF: triceps + subscapular + suprailiac + supraspinale + midthigh + medial calf; TER: Trunk/extremity skinfold ratio - FM: fat mass; LBM: lean body mass; SAD: Somatotype Attitudinal Distance. Somatotype categories (Carter17). $p < 0.05$; data are shown as mean ± SD; Student's t test for unpaired data

during the last ten years (data not shown).

Anthropometric analyses provided discrete alterations between the two groups in the decade under analysis. Only two SKF thicknesses and one circumference showed any difference. Whereas the 2001 female athletes had a greater supraspinale SKF thickness, those of the 2011 group revealed a higher thigh SKF thickness and a greater circumference in the tensed forearm. TER, which indicates accumulation of subcutaneous fat on trunk and extremities, registered a decrease in fat contents in the trunk region for 2011 female athletes. The somatotype analysis corroborates with changes in muscle mass and in body fat between the two groups of female athletes. Whereas fat component (mesomorphic-endomorphic) was predominant in 2001 female athletes (5.0-3.3-2.1), the physical profile of the 2011 female athletes (4.5-4.1-2.0) indicated a balance between muscular development and body fat (mesomorphic-endomorphic). The 2001 and 2011 physical profile of female futsal athletes, with a predominance of endomorphy, differs from that of soccer players. Mean somatotype of seventeen footballers from Turkey achieved 3.1-3.6-2.4¹⁸ and Australian athletes registered 4.2-4.6-2.2¹⁹. In other words, the two groups had a mesomorphy-predominant somatotype. Young soccer athletes (16.0 ± 0.5 years) also demonstrated a predominantly mesomorphic somatotype, with 3.0-3.9-2.6²⁰. A study on female Greek athletes revealed a balanced endomorphic profile for volleyball players (3.4-2.7-2.9) and a mesomorphic-endomorphic profile for basketball (3.7-3.2-2.4) and handball (4.2-4.7-1.8) athletes²¹. Since female athletes in different sport modalities (soccer, volleyball, basketball, handball) have a predominantly mesomorphic somatotype profile, such characteristic may also be preferred in futsal. Data above underscore that Brazilian female futsal athletes requires further mesomorphic and endomorphic alterations with an increase/maintenance in muscular mass and decrease in body fat.

Although the somatotype profile of the 2001 and 2011 athletes has changed, no difference between the two groups has been detected by SAD (0.5), which indicates significant dispersion between the two somatotypes when there are more than two units.

Fat amounts are essential for female organic functions, nevertheless fat excess may negatively affect performance in sport. There was only a slight decrease in mean rates for body fat percentage between the 2001 and 2011 female athletes (23.2 ± 5.2 vs. $22.2 \pm 5.2\%$; $p = 0.131$). Investigations on body fat in futsal athletes revealed a mean 23.3 % rate in Iranian female players²² and 19.8% and $22.8 \pm 2.2\%$ in Brazilian university athletes^{23,24}. Studies on the relative fat rates of professional soccer players reported 21.1 % in athletes of the British team²⁵, 19.8% in Turkish athletes¹⁸, 22.0% in Australian athletes¹⁹, 23.9% in Greek athletes²⁶ and 22.1% in young Canadian athletes²⁰. The above studies demonstrated a fat variation between 19.8% and 23.9% among soccer and futsal athletes.

Kooshakia et al.²² investigated the relationship between body composition profile and basic futsal skills in elite female futsal players. Researchers showed that there was no relationship between factors of body combination (height, weight, body fat percentage and body mass index) and basic skills, such as control and shooting. There was, however, a negative and significant relationship between body fat percentage and dribble skills. Although dribble skills were not assessed in the present study, it is suggestible that the decrease in body fat and increase in mesomorphic profile in our athletes could correlate to this type of improvement as well. Nevertheless, future studies aiming to determine cause-effect analysis between anthropometric changes and physical/technical improvements are needed.

Analysis of practice time (i.e., “years of playing”), age and anthropometric variations of athletes according to their playing function on the field (goalkeeper, wings, pivot and fixed) demonstrated temporal changes highly similar to those registered for total athletes. No difference in age was registered among the position of futsal players. However, with the exception of the pivots, the 2011 group’s practice time was longer than that for the 2001 athletes. When controlled for the years of playing in the positions that presented significant differences for the own time of practice, most of differences previously observed without controlling remained, except for midthigh and biceps girth (tensed) for the goalkeepers, endomorphy for the wings and mesomorphy for the fixed.

Variation trends for anthropometric measures between female futsal athletes according to their function on the field showed that supraspinale SKF thickness and mesomorphy were different in all tactic functions when compared to those of the 2001 athletes. There was only one exception for the variable “mesomorphy”, which no longer showed significant results after controlling for years of playing in the fixed position players.

Other alterations between the two groups of athletes (Table 2) highlight an increase in muscularity (mesomorphy) and a slight decrease in body fat (endomorphy) of the 2011 athletes. Somatotype changes for the 2011

group corroborate futsal's physical and motor requirements. In other words, futsal is a high-intensity, intermittent sport in which accelerations and short sprints are performed at maximal or almost maximal intensity, interspersed by brief recovery periods, during a relatively long period of time^{3,27}.

Furthermore, although futsal requires fast movements with and without the ball and no predetermined positions²⁸, the athletes' movements on the field, except that of the goalkeeper, are established by the team's tactic strategy and frequently the athletes perform different types of functions during the game (wings, pivot or fixed). However, the definition of the tactic function on the field was obtained by directly questioning the athlete and confirmed by the team's coach. It should be underlined that the tactic structure that establishes the players' positions in futsal (wings, pivots and fixed) still prevails and is very well-determined.

Although the somatotype classification (mesomorphic-endomorphic) for the 2011 goalkeepers remained the same as that in 2001, increase in muscular perimeter and a lower supraspinal SKF thickness were the most relevant structural modifications for the goalkeepers during the last ten years. The above changes do not actually reveal the important role that goalkeepers have in contemporary futsal technical and tactic aspects. More significant changes in the rules governing goalkeepers as from 1997¹ increased their technical requirements due to a greater freedom in their activities with their feet outside the goal area. The line goalkeeper's tactic system is characterized by a player in the center of the field, normally a goalkeeper, and four players positioned within the adversary defense area²⁹. The system (line goalkeeper) is mainly employed at the end of the game, when the team is at a disadvantage and aims at establishing a numerical superiority in the attack. The strategy favors exchange of passes among the players so that the finalization to the adversary team could be established. The above changes developed capacities in the goalkeeper's function such as passes, dominion and finalization, formerly restricted to line players. In addition, the possibility that the goalkeepers may attack requires higher physical capacities and morphological characteristics with an increase in the participation of the muscular component (mesomorphy). Nevertheless, high fat percentages in futsal female goalkeepers ($26.7 \pm 4.8\%$; $28.4 \pm 11.9\%$)^{23,30} and in soccer ($27.8 \pm 2.6\%$) are still extant²⁶.

When morphological changes in athletes playing on the field sides as wings and in the attack as pivots and in defense as fixed are detailed, results indicate a discrete but relevant evolution in the physical characteristics of the 2011 group. Whereas the 2001 outfielders (wings, pivot and fixed) exhibited a mesomorphic-endomorphic profile³⁰, the 2011 athletes featured a mesomorphic-endomorphic somatotype. Whereas the 2001 outfielders had a predominance of fat components, the 2011 athletes developed towards an average physical profile which indicated a balance between muscular development and body fat percentage. Greek female soccer players, divided according to game position, revealed a mesomorphic-endomorphic profile and a body fat percentage for defenders (4.7-4.4-2.3; 21.7%) and midfielders

(5.4-4.9-1.9; 23.6%) and a mesomorphic-endomorphic profile for attackers (4.9-4.0-2.1; 22.3%)²⁶, similar to futsal female athletes in current study.

Since predominant mesomorphic component is a characteristic of female soccer players¹⁸⁻²⁰, probably futsal female athletes, goalkeepers or outfielders also require greater muscularity for their morphological characteristics. A predominantly mesomorphic body type seems to be more expected for playing futsal, characterized as a dynamic sport and demanding physical features underscoring speed, power and muscle force^{3,27,28}.

One limitation of the study relates to the impossibility of identifying the possible causes for morphological alterations between the two athlete groups. Although coaches who have followed the sports for many years underscored that a female futsal game in 2011 required more speed, agility and power than those required in a 2001 match, the level of physical demands in the evaluated competitions (2001 and 2011) was not quantified. Nonetheless, considering the variable that changed between 2001 and 2011 (e.g., years of playing), it was possible to control for this variables as a covariate in the analyses that presented significant results. It should be underlined that variations in anthropomorphic indexes should not suggest a unidirectional and uninterrupted feature. However, the application of secular studies or morphological alterations in sport may contribute towards the influences that modifications in rules, game patterns and tactic strategies exert on the physical and physiology of female athletes over time. In fact, rules affect the characterization of tasks in sports and futsal has adopted several changes during the last years to make the sport even more dynamic. Since current study is the first to investigate morphological changes in female elite futsal players throughout a decade, comparison of our results was somewhat jeopardized by the low number of published studies, already reported in the literature⁵.

On the one hand, the analysis of variation in the anthropometric profile for female futsal players during the last ten years was positive for muscular development (mesomorphy) and negative for body fat percentage (endomorph); on the other hand, most anthropometric measurements remained unchanged. Decrease in body fat percentage and increase in muscularity contribute towards an increase in speed, agility and power, or rather, abilities highly relevant for futsal^{27,28}. Current physical characteristic (mesomorphic-endomorphic) which may develop into a predominantly mesomorphic component should be very close to the morphology of the Brazilian female futsal player.

CONCLUSION

We may conclude that the 2011 group showed a significant increase in practicing time, coupled to higher mesomorphy and lower endomorphy rates than those experienced by the 2001 athletes. The practical applications of providing estimates of morphological changes over time is the added value to training process, assessments of performance profile and new

specific information to coaches to improve practices in terms of developing morphological status in female futsal players.

Acknowledgments

The authors would like to thank the futsal players for their participation in current study.

COMPLIANCE WITH ETHICAL STANDARDS

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. This study was funded by the authors.

Ethical approval

Ethical approval was obtained from the local Human Research Ethics Committee – Universidade Estadual do Centro-Oeste (UNICENTRO) and the protocol (no. 039/2011) was written in accordance with the standards set by the Declaration of Helsinki.

Conflict of interest statement

The authors have no conflict of interests to declare.

Author Contributions

Conceived and designed the experiments: MRQ, SAF. Performed the experiments: MRQ, SAF, BSP, MPT, TGC. Analyzed the data: TGC, DFS, MRQ. Contributed reagents/materials/analysis tools: MRQ, DFS, TGC, MAN. Wrote the paper: MRQ, DFS, TGC, SAF, BSP, MPT, MAN.

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Corresponding author

Marcos Roberto Queiroga
Universidade Estadual do Centro-Oeste (UNICENTRO),
Departament of Physical Education. Guarapuava, PR, Brazil.
Simeão Camargo Varela de Sá street, 03, Cascavel District,
Zip code: 85040-080
E-mail: queirogamr@hotmail.com