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Perfil de composición corporal de los estudiantes de la Escuela Nacional de Circo de Brasil
Body composition profile of Brazilian national circus school students

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Abstract. Problem Statement. Professional education in circus has been increasing worldwide, placing the training programmes at the center of circus debate. Purpose. Concerning the physical demands of circus students, this research describes the body composition of Brazilian National Circus School students. Approach. Skinfold analyses was used to estimate body fat (%), fat free mass (kg) and body mass index (kg/m^{-2}) in 57 students (n= 30 men, n= 27 women). Results. Men presented higher body weight, height, fat free mass (men 67.2 ± 7.0 kg and 45.7 ± 4.7 kg and for women), body mass index (men 24.1 ±1.6 kg/m^2 and women 21.4 ± 2.0 kg/m^2) and lower body fat (%) compared to women (men 7.2 ± 3.7 % and women 16.3 ± 3.7). The reassessment showed no differences in body composition for both sexes, a large heterogeneity of interindividual responses was observed (-3.9 to 4.0 for women; -1.5 to 6,5 men). Conclusions. The body fat and body mass index are similar to high performance athletes. No difference was observed between the assessments. The interindividual response to training showed no effect on body fat. However, the interindividual heterogeneity responses suggest adjustments of physical conditioning protocol in order to optimize the responses individually. The 7 or 3 skinfold protocol did not differ on the outcomes. Body composition of circus students' needs to take into account the circus disciplines, age and biological diversity, and it is a key aspect to monitor training to avoid unsafe situations or unhealthy status.
Keywords: performing arts; anthropometry; body mass; physical training.

Resumen. Planteamiento del problema. La formación profesional en circo ha ido en aumento a nivel mundial, situando los programas de formación en el centro del debate circense. Objetivo. En cuanto a las demandas físicas de los estudiantes de circo, esta investigación describe la composición corporal de los estudiantes de la Escuela Nacional de Circo de Brasil. Método. Se utilizaron análisis de pliegues cutáneos para estimar la grasa corporal (%), la masa libre de grasa (kg) y el índice de masa corporal (kg/m-2) en 57 estudiantes (n= 30 hombres, n= 27 mujeres). Resultados. Los hombres presentaron mayor peso corporal, talla, masa magra (hombres 67,2 ± 7,0 kg y 45,7 ± 4,7 kg y mujeres), índice de masa corporal (hombres 24,1 ± 1,6 kg/m2 y mujeres 21,4 ± 2,0 kg/m2) y menor grasa (%) en comparación con las mujeres (hombres 7,2 ± 3,7 % y mujeres 16,3 ± 3,7). La reevaluación no mostró diferencias en la composición corporal para ambos sexos, se observó una gran heterogeneidad de respuestas interindividuales (-3,9 a 4,0 para mujeres; -1,5 a 6,5 hombres). Conclusiones. Los índices de grasa corporal y masa corporal son similares a los de los deportistas de alto rendimiento. No se observaron diferencias entre las evaluaciones. La respuesta interindividual al entrenamiento no mostró efecto sobre la grasa corporal. Sin embargo, las respuestas de heterogeneidad interindividual sugieren ajustes del protocolo de acondicionamiento físico para optimizar las respuestas individualmente. Los protocolos de 7 o 3 pliegues cutáneos mostraron resultados similares. La composición corporal de los estudiantes de circo necesita tener en cuenta las disciplinas circenses, la edad y la diversidad biológica, y es un aspecto clave para monitorear el entrenamiento para evitar situaciones inseguras o estados insalubres.
Palabras-clave: artes escénicas; antropometría; masa corporal; preparación física.

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Introduction

Although circus has been present in Brazil since the beginning of the XIX Century (Silva, 2015), the scientific interest of this art form trajectory according to recent studies only started after 1980 (Ontañón, Duprat & Bortoleto, 2012).

It has been noticed in the last two decades a significant increase of circus activities as recreational, educational or vocational practice, gathering millions of children, youths and adults in many countries (Hotier, 2001). Particularly, the regular called "circus schools" are growing exponentially all over Brazil and represents one of the most relevant aspects to the contemporary circus development (Bortoleto, Ontañón & Silva, 2016). There are strong evidences indicating that this is a worldwide phenomenon (Leroux & Batson, 2016).

The National Circus School (NCS) of Rio de Janeiro in Brazil, is recognized as the major national reference in Circus education, training generations of well national and international recognized artists (Barreto, Depart & Bortoleto, 2021). NCS was founded in 1982 by the National Arts Foundation (FUNARTE) and regulated by the Ministry of Culture. In 2017, the official denomination was update to "Escola Nacional de Circo Luis Olimecha in honor of its founder (FUNARTE, 2020).

The certification offered by the NCS, in partnership with the Federal Institute of Rio de Janeiro (IFRJ), is recognized by the Ministry of Education since 2014 been officially implemented in 2015 (Dos Santos, 2017). The NCS curriculum was recently reformulated highlighting the importance of physical conditioning to the circus art professional training (FUNARTE, 2020). This program is free of charge and in the last years, every selected student received a monthly scholarship support (Silva, 2015), allowing the students to dedicate themselves fulltime in a two-year program. The training program goes from Monday through Friday, making 22 to 30 hours of activities weekly turning the workload comparable to high performance athletes (Shrier et al., 2009; Decker, 2020). The intensive training requires specific assessments, planning and monitoring (Bompa & Haff, 2009), aiming efficiency in

the body preparation process, prevention of injuries and burnouts (Goudard & Chardon, 2010). Therefore, an adequate physical conditioning is the key element to reduce the risk of injuries and enhance performance (Ramirez, 2005), as recommended by the European Federation of Professional Circus Schools (FEDEC) (Demey & Wellington, 2010). The training workload may affect health, well-being and artistic performance; it is definitely a critical issue to protect circus students, to optimize the economical investment and to enhance quality of performance (Wanke et al., 2012; Prior et al., 2015), mainly concerning the contemporary circus (Decker, 2020).

There is little information about body composition concerning professional circus school students. In order to provide more accurate data, as suggested by Hakim et al. (2018) and Decker (2020), the goal of this study is to describe the body composition of Brazilian NCS students, believing it will support the training work load planning, as well as, the resting hours, energy needs, food intake and replacements recommendation for individual or specific groups of students.

Materials and methods

Participants

The anthropometric data was assessed in 57 out of the 60 students older than 18 years, enrolled at the CNS course - 2017/19, the students were assessed in two moments: five months after the first year-course started (M1) and 18 months later, right after 2 weeks of their graduation (M2). However, only 34 students have participated of the reassessment (19 men/15 women), due to their commitments right after the graduation. One (1) student passed away, two (2) didn't finish the course and the others left school before the second data collection because of personal reasons. Students absent for more than 60 days were excluded. The sample was heterogenic, since the students were from Brazil, Venezuela, Argentina and Italy, so that the body composition was in accordance, first to their backgrounds (Africans, Europeans, South American and Natives) and then the body differences, according to the circus discipline they mostly performed. The training program was 5 days a week, summing up from 22 to 30 hours of activities weekly, what made the workload comparable to high performance athletes. The University of Campinas Ethical Commission under the protocol 2.365.618 approved the research's procedures.

Measures

The body composition assessment was developed in a private room with preview appointment; it was developed in presence of at least two researchers and one instructor of CNS. The subjects were oriented to dress appropriately with a tank top and a pair of shorts for women, and a pair of shorts and no t-shirts for men.

Design and Procedures

Weight in kilograms (kg), was assessed twice by the use of two portable weight scales (Mechanic scale - G-Tech Sport; Digital scale - Mallory Syncro Glass), the average between these two data was used as final data. Height in meters (m), was assessed by a portable stadiometer (AVANUTRI - BCN/ISO-IEC 17025). Body mass index (BMI), was assessed in kilograms by squared meters (kg/m^{-2}). The waist circumference (WC), was measured by a tape-measure of 0,1 cm precision, above the umbilical scar. For fat and free fat mass assessment, it was applied Jackson & Pollock (1978) protocol for men and Jackson, Pollock & Ward (1980) protocol for women. Body fat was checked three times by both 3 skinfolds protocol (chest, abdomen e thigh for men and triceps, iliac crest and thigh for women); and the 7 skinfolds protocol (subscapular, triceps, axillar, chest, abdomen, iliac crest and thigh, for both sexes), the two protocols were considered in order to search for a better reliability between the outcomes (Petroski, 2007). The skinfold caliper used was LANGE - 1,0 mm precision and 10 $g.mm^{-2}$ constant pressure (Beta Technology Incorporated). All folds were taken on the right side of the body by a single researcher on the attempt to minimize bias.

Statistical Analysis

Data distribution, for all variables, was checked by Shapiro Wilk's test and skewness measures (standardized skewness $< |2|$ as a major acceptable normality deviation). For all participants' characterization profile and comparisons between sexes, Student's *t* test was applied. To assess the association of body fat mass with participants' age, Pearson correlation coefficient was applied. To analyze the effects of sex and training program on each dependent variable, a Mixed Linear Model, was used assuming the gender (woman and man), moment (M1 and M2 – repeated-measure effects), and interaction (sex*moment) as fixed factors, and participants as a random factor. Whenever a significant F value was obtained, the Sidak adjustment was performed to verify where the differences resided and also for multiple-comparison purposes. To analyze the interindividual responses to training program, the distribution of body fat mass was presented and the individual response threshold was based on one-fifth of the between-subject standard deviation M1 (0.2*SD), which has been previously suggested as the smallest worthwhile effect (Hopkins, Hawley & Burke, 1999). Then, participants were classified in three response levels based on magnitude of changes in body fat mass after training program as: Positive Responder for reduction greater than 0.2*SD; Non-responder for changes between $\pm$0.2*SD; and Negative Responder for an increase greater than 0.2*SD. To compare the frequency of participants with different response levels between sexes, the Chi-square test was applied. Additionally, Bland-Altman procedure was applied to assess agreement between body fat mass values assessed by the two protocols (7 and 3 skinfold), including plots with mean difference (bias) and 95% limits of agreement (Bland, Altman, 1986). After, the measurement error was analyzed by the simple linear regression of

differences between the two protocols and the mean of the two protocols. Finally, the score differences between the two protocols were compared to zero by using One Sample *t* Test. For all statistical procedures, the significance level was set at 5% ($P < 0.05$). For Data analysis it was used Predictive Analysis Software (PASW) Statistics 18.0 SPSS Inc., 2009).

Results

Table 1.
Participants characterization

Variables	Women (n = 27)			Men (n = 30)			All (n = 57)		
Age (years)	24.2	±	3.3	23.8	±	3.0	24.0	±	3.1
Body mass (kg)	54.7	±	6.3	72.7	±	9.6*	64.2	±	12.2
Height (m)	1.60	±	0.05	1.74	±	0.07*	1.67	±	0.09
Body mass index (kg.m^{-2})	21.4	±	2.0	24.1	±	3.0*	22.8	±	2.9
Fat mass (7 skinfold, %)	16.3	±	3.7	7.2	±	3.7*	3.7*	±	11.5
Fat mass (3 skinfold, %)	17.3	±	4.4	6.3	±	3.3*	11.5	±	6.8
Fat mass (kg)	9.1	±	2.7	5.5	±	4.0*	7.2	±	3.9
Fat free mass (kg)	45.7	±	4.7	67.2	±	7.0*	57.0	±	12.4
Waist circumference (cm)	68.7	±	11.5	78.2	±	7.5*	73.7	±	10.6

Data are mean ± standard deviation. * $P < 0.01$ compared to women.

Participant's characterization. The sample was represented by young-adults. There were no significant differences for age in years between women and men ($P = 0.633$). Men presented higher body weight, height, body mass index, fat free mass percentage, waist circumference and lower fat mass percentage compared to women ($P < 0.001$ for all, **Table 1)**. There was no significant correlation between fat mass percentage and age for women, men or all participants ($P > 0.05$ for all, **Figure 1**).

Training effects. There were no significant differences in body composition when compared M2 to M1 for both sexes. Men presented higher body weight, height, body mass index, fat free mass percentage, waist circumference and lower fat mass percentage compared to women in M1 and M2 ($P < 0.001$ for all, **Table 2**). However, no significant interaction sex*moment was observed ($P < 0.05$ for all, **Table 2**). The almost 2 years of training program had no impact in the body composition.

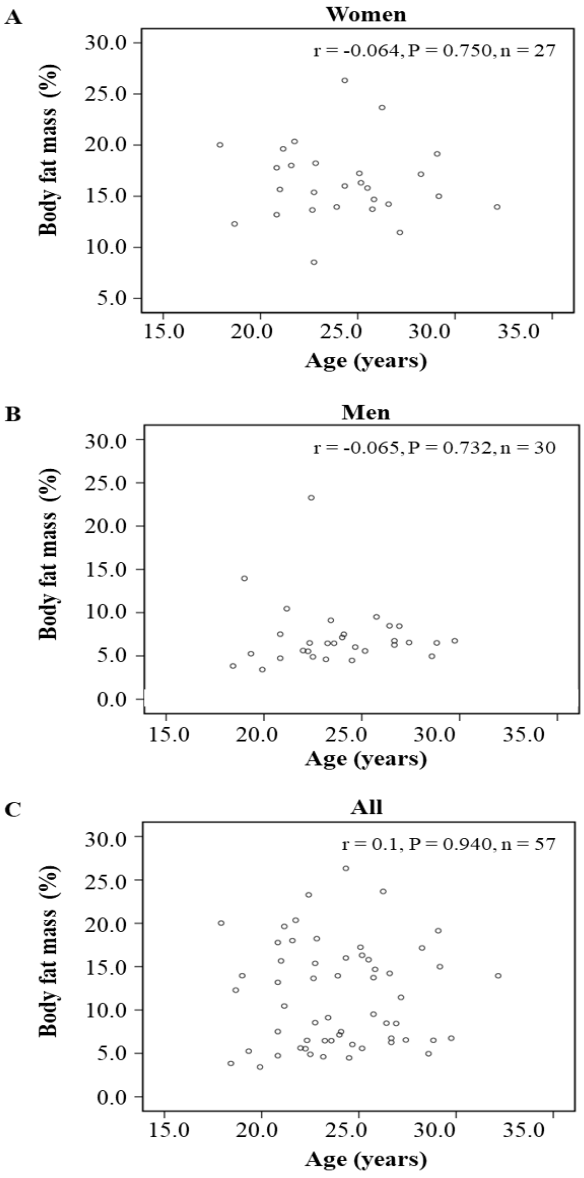

Figure 1. Association between body fat mass (seven skinfold protocol) and age.

Table 2.
Training program effects.

Variables	Women (n = 15)				Men (n = 19)				All (n = 34)			
	M1			M2	M1			M2	M1			M2
Age (years)	24.8	±	2.8	26.3 ± 2.8†	23.9	±	2.5	25.4 ± 2.5†	24.3	±	2.6	25.8 ± 2.6†
Body mass (kg)	53.9	±	6.2	53.2 ± 6.4	71.9	±	6.4*	73.0 ± 7.7*	64.0	±	11.0	64.3 ± 12.3
Height (m)	1.60	±	0.06	1.61 ± 0.07†	1.74	±	0.07*	1.76 ± 0.07*†	1.68	±	0.09	1.69 ± 0.10†
Body mass index (kg.m^{-2})	21.4	±	2.0	20.4 ± 1.4	24.1	±	3.0*	23.6 ± 1.9*	22.4	±	2.2	22.2 ± 2.3
Fat mass (7 skinfold, %)	17.1	±	3.8	16.8 ± 3.9	6.4	±	1.6*	7.1 ± 2.8*	11.1	±	6.0	11.4 ± 5.8
Fat mass (3 skinfold, %)	18.0	±	4.5	17.5 ± 4.3	5.6	±	1.5*	6.3 ± 3.0*	11.1	±	7.0	11.2 ± 6.7
Fat mass (kg)	9.3	±	2.8	9.0 ± 2.8	4.6	±	1.3*	5.3 ± 2.4*	6.7	±	3.2	6.9 ± 3.2
Fat free mass (kg)	44.6	±	4.6	44.1 ± 4.6	67.3	±	5.9*	67.7 ± 6.6*	57.3	±	12.6	57.3 ± 13.2
Waist circumference (cm)	66.4	±	14.3	68.3 ± 3.8	77.5	±	3.4*	77.5 ± 4.9*	72.6	±	11.2	73.4 ± 6.4

Data are mean ±standard deviation. * $P < 0.01$ compared to women. † $P < 0.01$ compared to Pre training.

Interindividual responses to training program.

Although, there was no significant effect of training on the percentage of body fat (BF%), a large heterogeneity of interindividual responses was observed (-3,9 to 4.0 for women; -1,5 to 6,5 men) (fig.2). For women, BF% training responses ranged from -3.9% to 4.0% for 7 skinfold protocol and -5.3% to 4.3% for 3 skinfold protocol (**Figure 2A and 3A**). For men, BF% training responses ranged from -1.5% to 6.5% for 7 skinfold protocol and -2.0% to 7.6% for 3 skinfold protocol (**Figure 2B and Figure 3B**). Nevertheless, there was no significant association between frequency of different response levels and

sex for 7 or 3 skinfold protocols (P = 0.864 and P = 0.950). Frequency of responses levels ranged from: 33-42% for Positive Responders, 16-20% for Non-responders and 42-47% for Negative Responders using 7 skinfold protocol; and 40-42% for Positive Responders, 16-20% for Non-responders and 40-42% for Negative Responders using 3 skinfold protocol, for both sexes.

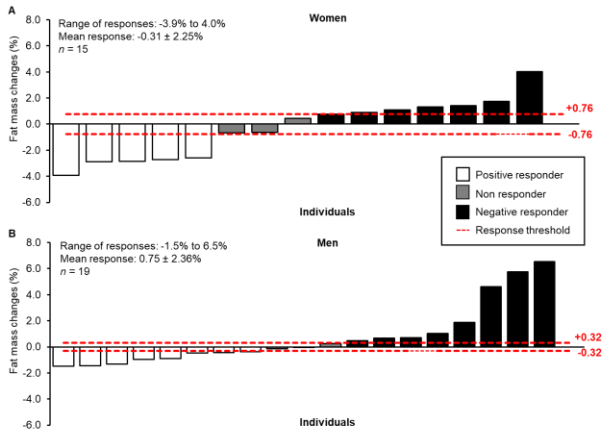

Figure 2. Variability of interindividual response for body fat mass calculated by seven skinfold protocol. Response threshold was based on one-fifth of the between-subject standard deviation at baseline, which is taken as the smallest worthwhile effect (Hopkins, Hawley and Burke, 1999).

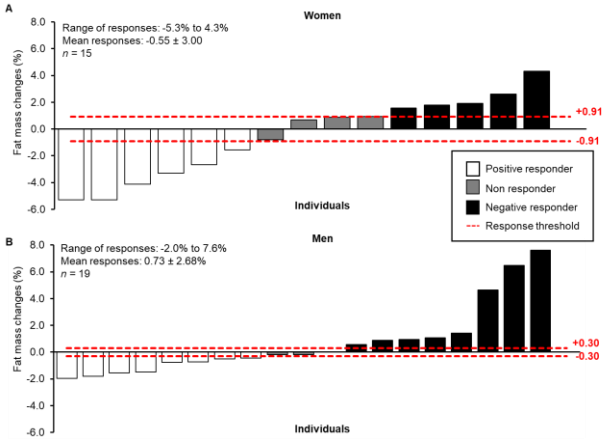

Figura 3. Variability of interindividual response for body fat mass calculated by three skinfold protocol. Response threshold was based on one-fifth of the between-subject standard deviation at baseline, which is taken as the smallest worthwhile effect (Hopkins, Hawley and Burke, 1999).

Skinfold protocols difference. The analysis of agreement between methods (Bland–Altman) indicated that the average difference between 7 and 3 skinfold protocols was significantly different from zero for women ($P < 0.001$, mean difference = -1%, **Figure 4A**) and men ($P < 0.001$, mean difference = 1%, **Figure 4B**). Although the mean differences between protocols was small (±1%), there was a high within-participants variability evidenced by wide limits of agreement (women: -3.3% to 1.3%; men: -0.8% to 2.7%). Additionally, the measurement error for both women and men was proportional, as evidenced by significant slopes (B) derived from linear regression of differences between the protocols with mean values of the protocols.

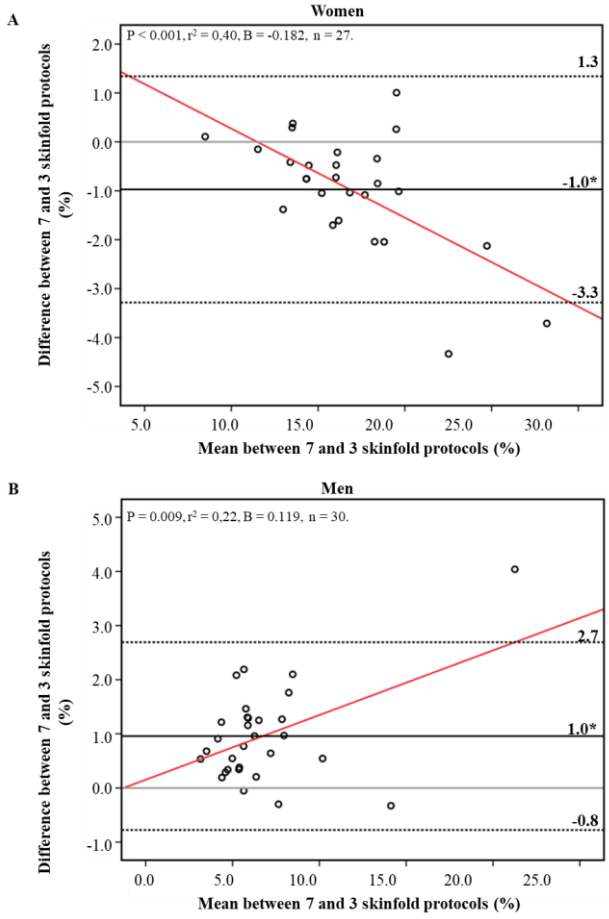

Figure 4. Bland and Altman diagram for differences between the measures of BF% between 7 and 3 skinfold protocols. The horizontal black and gray continuous lines indicate the average of the differences between the measurements (bias) and the zero mark, respectively. Continuous red line indicates the linear regression line between the errors (differences between measurements) and the mean of the 7 and 3 skinfold protocols measurements. The dashed black lines indicate the limits of agreement with 95% confidence (bias ± 1.96*standard deviation). * Significant difference between bias and zero (P <0.05).

Discussion

Body shape in circus, as well in dance or other artistic sports disciplines, assumes a relevant role, beyond the aesthetical expectations. Combining to that, the high physical demand turns the body composition a relevant variable to balance health and performance. Often, circus artists face intensive training looking for higher performance levels, which requires constant monitoring of its practice in order to avoid overtraining, injuries and others health problems (Bolling et al., 2019). This is the case of the professional circus school students from NCS, which the body profile became an important indicator in order to monitor their training process, although, the scientific literature misses this kind of information.

According to the American Council on Exercise (ACE., n.d.), the BF% expected for athletes ranges from 6 to 13% for men and 14 to 20% for women. The NCS students presented their BF% in accordance to ACE. No significant results were found between men and women students for

BF%, FFM and BMI in M1 and M2. It is worthy to mention that M1 was taken after 5 months the activities had started at NCS, which did not allow the assessment of their body composition profile by the time they started; and M2 was taken two weeks after the target time for final performance, when they should have been at their peak of optimal physical condition. This situation allows hypothesizing reasons why there have been no differences after 18 months of intensive training.

Comparing the NCS students' body composition to high performance athletes, mainly in sports where reduced weight or low BF% is expected due to the aesthetic and performance requirements (Acrobatics, Artistic and Rhythm Gymnastics), we noticed that women showed higher percentage of BF% when compared to Spanish acrobats (Toboada-Iglesias, Gutiérrez-Sánchez & Vernetta, 2015), Portuguese acrobats (Silva, Silva & Paiva, 2018), and Brazilian gymnasts (Ferreira & Fernandes Filho, 2015), but lower than Russian Ballet Dancers (Mihajlović & Mijatov, 2003). For men, the opposite was observed, they showed lower BF% than the Spanish acrobats (Toboada-Iglesias, Gutiérrez-Sánchez & Vernetta, 2015), American gymnasts (Deutz et al., 2000) and Portuguese acrobats (Silva, Silva & Paiva, 2018).

So far, the only comparison we can make with professional circus students is with the recent study developed by Decker (2020), who used a more accurate method (DEXA) for body composition assessment of Montreal National Circus School students and finding a very similar result to ours. Concerning BF%, his results showed 16.2% for woman, 8.9% for men and 11.5% for all; while our study was found 16.8% for woman, 7.1% for men and 11.4% for all.

Male subjects presented lower BF% and larger FFM, pointing to a heavy but lean BMI 23,6 (± 1,6) very much close to the athletic parameters, as found 23,7 in men gymnast (Sterkowicz-Przybycień et al., 2019). And for women, the eutrophic BMI of 21,4 (± 2,0) (Sands, 2012).

It´s also worth to say that our sample was composed not only by Brazilians students, but also from countries as Venezuela, Argentina and Italy. This could explain a great heterogenity in the body composition of the students in accordance to their backgrounds (Africans, Europeans, South American and Natives) as well as differences in body demands from each circus discipline. A similar diversity in population was noticed by Decker (2020) in Canada. This suggests that biological diversity should be an aspect to be taken into account when a multinational circus school's students is analyzed. Comparative studies with the Latin American population of the same age may help to understand the particularities of the anthropometric profile of young circus artists, as suggested by studies such as that by Pinto Guedes, César Franzini, Pires Júnior & Moya Morales (2017).

The interindividual responses to training, although there was no significant effect of it on the group BF%, a large heterogeneity of interindividual responses was verified suggesting the need of an individual adjustment of the physical conditioning protocol, in order to optimize the responses.

According to FUNARTE (2020), the NCS curriculum includes a strong physical conditioning program in the first year, however by the second year, the students must specialize in one individual and one group circus discipline, which brings to a specific training program along this period. Therefore, it is necessary to consider the specific body demands (jugglers; acrobats – base or top; trapeze - catchers or flyers; teeterboard acrobats; "handstanders"; contortionists, aerials, etc.) as previous studies already suggested (Hakim et al., 2018).

Even though the body composition parameters found was similar to high performance athletes, it is also important to analyse closely the outliers. For instance, at M1 one female presented 8,54 BF% and a male 23,28%, showing they were in situations that needed closer attention to the training process. In high level performance, every little change in body composition can be of a great result, so that an intra-individual analyses should be considered for futures studies.

In general, the BF% and FFM monitoring may help planning the training load, resting hours, food intake estimation (quantity and quality), respecting the physiological and psychological individual parameters (Decker, 2020). Other variables are also interesting to be investigated, as the aerobic capacity, eating habits, resting and sleeping hours, in order to compare artists to athletes (Vieira Santos et al., 2023).

For future studies, it will be important to describe differences between circus disciplines and body profile. We know the trapeze catcher or acrobatic base need larger muscle mass for a better performance, which can be very different from the juggler, clown or some other discipline in professional circus schools. Studies on workload would also be interesting for crossing out information of its intensity on body composition, besides the consideration of peak of performance.

Concerning the method used to assess body composition the results suggested the difference magnitude observed between 7 and 3 skinfold protocols, could be inflated by increasing the individual body fat mass. However, in this population either 7 or 3 skinfold assessment did not differ from each other. Even though more accurate methods than the skinfold anthropometry are available, as DEXA or BIAS (Gomes et al., 2020), the presented data is reliable enough, very convenient and economic. In our opinion, it is useful to provide reliable data to monitor the training effects when trained staff, financial support and other required aspects are limited.

Conclusion

The body composition profile for circus artist/performers is important for planning the training strategies. More studies are required to describe body composition profile according to the very different circus disciplines and roles.

The regular monitoring process of these variables can support the training goals, performance improvements and keep track of health status. Thus, the high workload these young-adults are exposed requires permanent attention to body composition components. We also recommend the assessment timing as fundamental, suggesting to be taken in the first week program and right before their final examination, when the students are in their peak of physical preparation. Future studies should consider other components as calories/nutrients intake, training periodization and also limitations imposed by the biological-genetics features. It seems, after all, that more efforts are needed to better understand the role and the impact of body composition for vocational circus training.

Conflicts of interest

The authors have no conflicts of interest to declare.

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