ARTIGO ORIGINAL

Comparative study of anthropometric variables in female classical ballet dancers, volleyball players and physically active subjects

Estudo comparativo das variáveis antropométricas em bailarinas clássicas e jogadoras de voleibol

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Resumo – O objetivo do presente estudo foi comparar medidas antropométricas (massa corporal, estatura e percentual de gordura) e a amplitude de movimento (ADM) de dorsiflexão e plantiflexão entre três diferentes grupos: bailarinas clássicas (n=14), jogadoras de voleibol (n=22) e mulheres fisicamente ativas (n=13). Assumiu-se que diferentes demandas funcionais deveriam produzir alterações nas medidas antropométricas e de ADM entre os três grupos. A massa corporal e a estatura foram maiores nas atletas de voleibol (66,42 ± 5,8 kg; 174,77 ± 5,6 cm), seguidas das mulheres fisicamente ativas (59,93 ± 10,3 kg; 164 ± 7,5 cm) e das bailarinas clássicas (49,25 ± 4,5 kg; 157,03 ± 3,6 cm), respectivamente (p<0,05). O percentual de gordura foi maior nas mulheres ativas (30,67 ± 4,6%) quando comparadas aos outros dois grupos, que foram semelhantes entre si (jogadoras de voleibol = 24,93 ± 4,1%; bailarinas = 21,94 ± 4,3%, respectivamente). Os três grupos apresentaram semelhante ADM entre os lados direito e esquerdo e para a amplitude de movimento ativa de dorsiflexão. Entretanto, para a plantiflexão a amplitude de movimento ativa foi maior nas bailarinas (~83°), seguidas das mulheres fisicamente ativas (~68°) e, por fim, pelas jogadoras de voleibol que apresentaram a menor amplitude de flexão plantar (~60°). As diferentes demandas impostas pelas três distintas atividades parecem ser responsáveis pelas mudanças em algumas variáveis antropométricas e na ADM da articulação do tornozelo.

Palavras-chave: Bailarinas; Jogadoras de voleibol; Bioimpedância; Variáveis antropométricas.

Abstract – *The objective of this study was to compare anthropometric variables (body weight, height, and percent body fat) and plantarflexion and dorsiflexion range of motion (ROM) between three different groups of women: classical ballet dancers (n=14), volleyball players (n=22) and physically active subjects (n=13). The assumption was that different functional requirements should produce differences in the anthropometric variables and ROM between the three groups. Body weight and height were higher in volleyball players (66.42 ± 5.8 kg; 174.77 ± 5.6 cm), followed by physically active women (59.93 ± 10.3 kg; 164 ± 7.5 cm) and ballet dancers (49.25 ± 4.5 kg; 157.03 ± 3.6 cm) (p<0.05). Percent body fat was higher in physically active women (30.67 ± 4.6%) compared to the other two groups, which showed similar percentages (volleyball players: 24.93 ± 4.1%; ballet dancers: 21.94 ± 4.3%). The three groups were similar in terms of total ankle ROM and active dorsiflexion ROM between the right and left sides. However, plantarflexion ROM was higher in ballet dancers (~83°), followed by physically active women (~68°) and volleyball players who presented the smallest ROM (~60°). The different requirements imposed by the three distinct physical activities seem to be responsible for changes in some of the anthropometric variables and ankle joint ROM.*

Key words: *Ballet dancers; Volleyball players; Bioimpedance; Anthropometric variables.*

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INTRODUCTION

Anthropometric (e.g., body composition) and physical (e.g., oxygen uptake) characteristics are related to an athlete's profile and might be used to predict an athlete's success. These parameters are potential indicators of sports performance, are mainly dependent on hereditary factors and are correlated with age, gender, ethnicity, and morphological characteristics[1-3].

Skeletal muscle properties depend on several factors such as fiber-type distribution, muscle architecture, muscle activation and systematic physical activity[4,5]. Functional demand has been proposed to be responsible for skeletal muscle adaptation[6]. If this was true, adaptation should not only occur in muscle tissue, but also in some of the surrounding tissues[7-10].

Functional adaptation due to different training regimens may be responsible for the determination of some anthropometric changes[11]. The number of hours per day and the number of days per week that a specific physical activity is performed may result in systematic changes in body composition[3]. In addition, the joint range of motion (ROM) may change in subjects with different functional demands placed on specific joints.

Classical ballet dancers and volleyball players differ in terms of joint ROM. The use of Pointe shoes and standing on tiptoes regularly increases the ankle plantarflexion range in ballet dancers[12]. In contrast, volleyball players present an ankle joint ROM similar to the normal population and work in a more dorsiflexed position than ballet dancers during training[2].

The purpose of the present study was to compare anthropometric variables such as body weight, height, percent body fat and plantarflexion and dorsiflexion ROM between three different groups of women: classical ballet dancers, volleyball players and physically active subjects.

MATERIAL AND METHODS

Forty-nine women participated in the study and were assigned to three different groups. The first group consisted of 14 elite classical ballet dancers (mean age ± standard deviation, 20.2 ± 3.7 years), with a minimum of 8 years of ballet dancing and a minimum of 2 hours of daily training, five times per week. The second group consisted of 22 volleyball players (15.8 ± 2.3 years), with a minimum of 4 hours of daily training, three times per week. The third group consisted of 13 physically active subjects (19.0 ± 4.3 years), who performed systematic physical activity at least three times per week. All participants signed an informed consent term to participate in the study (protocol No. 2006606), which was approved by the Ethics Committee of the Federal University of Rio Grande do Sul.

Body weight of the subjects was measured with a scale to the nearest 0.1 kg (Filizola model 31, São Paulo, Brazil). Height was measured in centimeters with a stadiometer (precision of 0.01 m; Filizola model 31).

Several different techniques are available for the determination of body composition (e.g., skinfold measurements, hydrostatic weighing and dual-energy X-ray absorptiometry - DEXA)[13,14]. DEXA is considered to be the gold standard for the measurement of body composition, but the method requires sophisticated and expensive technology. In contrast, bioelectrical impedance analysis is an easy, noninvasive, and relatively inexpensive technique. This method is based on several assumptions, which require the subject to be fully hydrated at the time of measurement[13]. In the present study, body composition was determined by a bioimpedance test using a body composition analyzer (Biodynamics, model 310, Biodynamics, Seattle, USA). For this analysis, two electrodes were positioned on the right foot and two electrodes on the right hand of the subject[1]. A low-frequency electric current was then transmitted through the electrodes, measuring the resistance of different types of tissue. The subjects were instructed regarding procedures that should be followed in order to avoid possible changes in their hydration state prior to the test. In addition, a minimum resting period of 48 hours between the last day of intense physical activity and the test day was adopted in order to avoid possible changes in hydration due to training, competitions or ballet presentations.

The ankle joint angles were measured with a universal plastic goniometer (precision of 1 degree; Carci, São Paulo, Brazil). The active plantarflexion and dorsiflexion ROM of the right and left ankle joints were obtained. With the subject seated and the knees extended, the

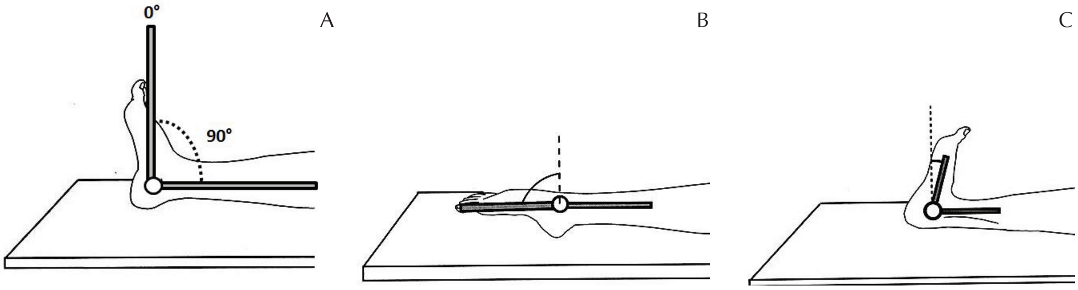

Figure 1. Neutral position, angle of zero degrees (A), and measurements in plantarflexion (B) and dorsal flexion (C) of the ankle joint.

Table 1. Age, training experience, amount of training time per week, body weight, height, and percent body fat of ballet dancers, volleyball players and physically active subjects.

	Ballet dancers (n=14)	Volleyball players (n=22)	Physically active subjects (n=13)
Age (years)	20.2 ± 3.7	15.8 ± 2.3	22.7 ± 4.3
Training experience (years)	8.4 ± 2.1	5.6 ± 1.9	2.2 ± 1.1
Training time per week (hours)	10 ± 3.1	10 ± 2.9	3 ± 1.2
Body weight (kg)	49.25 ± 4.5[a]	66.42 ± 5.8[a]	59.93 ± 10.3[a]
Height (cm)	157.03 ± 3.6[b]	174.77 ± 5.6[b]	164 ± 7.5[b]
Percent body fat (%)	21.94 ± 4.3	24.93 ± 4.1	30.67 ± 4.6[c]

Results are the mean ± SD. a=p<0.001 (F=13.702) for comparisons between groups; b=p<0.001 (F=41.801) for comparisons between groups; c=p<0.001 (F=24.198) for comparisons between physically active subjects and ballet dancers/volleyball players.

Table 2. Ankle joint plantarflexion and dorsiflexion range of motion in ballet dancers, volleyball players and physically active subjects.

	Ballet dancers (n=14)		Volleyball players (n=22)		Physically active (n=13)	
	right	left	right	left	right	left
Plantarflexion (º)	83.4 ± 5.1[d]	82 ± 5.2[e]	61.2 ± 8.3[d]	60.3 ± 7.6[e]	68.1 ± 6.1[d]	67.2 ± 7.6[e]
Dorsiflexion (º)	12.8 ± 4.3	12.2 ± 4.5	13.4 ± 3	13.9 ± 3.1	13.5 ± 3.7	13.7 ± 2.2

Results are the mean ± SD. d=p<0.001 (F=35.099) for comparisons of the right plantarflexion ROM between the three groups; e=p<0.001 (F=37.885) for comparisons of the left plantarflexion ROM between the three groups.

neutral position (angle of zero degrees) was defined as an angle of 90° between the foot and shank (Figure 1). From this position, measurements were made in the two directions, i.e., plantar- and dorsal flexion of the ankle joint[15]. The subjects were asked to actively dorsiflex and plantarflex the ankle joint in order to determine the ROM in each direction.

Statistical Analysis

One-way analysis of variance was used to determine significant differences in body weight, height and percent body fat between the three groups. One-way analysis of variance was also used to compare the following data between groups: plantarflexion on the right side, plantarflexion on the left side, dorsiflexion on the right side, and dorsiflexion on the left side. The Bonferroni post-hoc test was used to determine which groups were different. The level of significance was set at 0.05 for all tests. Results are reported as the mean and standard deviation (SD).

RESULTS

Table 1 shows the mean (and SD) body weight, height, and percent body fat of ballet dancers, volleyball players and physically active subjects, as well as age, training experience and amount of training time per week.

Body weight differed between the three groups. Volleyball players presented the highest body weight, followed by physically active subjects and ballet dancers who presented the lowest body weight. A similar pattern was observed for height in the three groups studied.

Differences in percent body fat were observed between physically active subjects and the other two groups, but not between volleyball players and ballet dancers. As shown in Table 1, physically active subjects presented the highest percent body fat.

The active dorsiflexion ROM was similar for the right and left ankle joints in all three groups. However, the active ankle plantarflexion ROM differed between groups (Table 2), with the largest plantarflexion ROM being observed for ballet dancers, followed by physically active subjects and volleyball players. This was observed for the right and left ankle joints.

DISCUSSION

The purpose of this study was to compare anthropometric variables between classical ballet dancers, volleyball players and physically active subjects, with the expectation that different types of systematic physical activity should produce different types of adaptation in these variables. Since the level of adaptation depends on the joint position selected for training[16], ballet dancers and volleyball players were chosen due to their systematic use of the plantarflexor muscles in different joint configurations. Ballet dancers use a high degree of plantarflexion resulting in shorter plantarflexor muscle length, whereas volleyball players use the same muscles in a more dorsiflexed position (greater plantarflexor muscle length). Changes in the amplitude of angular movement seems to occur when training involves a joint angle that results in a relatively short muscle length[17,18]. The physically active group was chosen as a control group for volleyball players since it was expected that they would have similar functional demands in terms of joint ROM[12].

A difference in age was observed between groups, with volleyball players being the youngest (15.8 ± 2.3 years) and physically active subjects the oldest (22.7 ± 4.3 years). Although the initial intention was to select groups of similar age and with similar experience in physical activity, this was not possible due to the lack of a female adult (or senior) volleyball team in the region (or in the State of Rio Grande do Sul). In addition, since the city of Porto Alegre does not possess any professional classical ballet group, the best ballet dancers (1-2) from each school of the city were chosen. Therefore, ballet dancers had more than 8 years of experience, whereas volleyball players had only 2-5 years of experience. Nevertheless, these athletes were included in the study because they were considered to be the best in the state in their specific modalities when the experiment was performed.

The body weight and percent body fat of ballet dancers were similar to those reported in previous studies involving Brazilian (20.3 ± 2.5%) classical ballet dancers[18] and young American (20.1 ± 3.6%) and Greek (19.4 ± 4.3%) classical ballet dancers[1,19,20]. The differences in height and body weight between ballet dancers and volleyball players can be attributed to genetic heritage of the athletes in each group. In this respect, volleyball players are expected to be taller and heavier compared to ballet dancers. This was confirmed by the greater height of volleyball players and the lower body weight of ballet dancers. Ballet dancing is a demanding career which requires a high level of self-discipline and motivation, excellent athletic performance, and maintenance of a lean body appearance. As a consequence, ballet dancers tend to restrict caloric intake to maintain a low body weight[14]. In other words, ballet dancers need to be light (low fat content and low body weight) and flexible in order to perform the tasks related to classical ballet, whereas volleyball players need to be tall and physically powerful to perform jumps, blocking and other volleyball-related tasks. According to Tsunawake et al.[21], the optimal percent body fat of female volleyball players is estimated to be 16-20%. The results of that study obtained for 12 Japanese volleyball players (17.4 ± 0.7 years) showed a lower mean percent body fat (18.4 ± 3.3%) than that observed in the present study (24.93 ± 4.1%). These variations might be due to genetic factors and differences in the activity level and years of training between the two groups of volleyball players[21]. Another possibility are differences in dietary habits between athletes from different cultural environments, which may also affect these results. The high percent body fat of physically active subjects (30.67 ± 4.6%) compared to the other two groups might be related to a smaller training regimen. In this respect, physical activity performed three times per week may not be sufficient to maintain percent body fat within the range indicated for age and gender[1].

Similar ankle joint dorsiflexion ROMs were observed in the three groups (Table 1). The reduction in dorsiflexion reported by Hamilton et al.[12] was not observed in the present study for ballet dancers. The dorsiflexion ROM observed here for the ballet group (~12.5°) is similar to that reported in a previous study involving Brazilian classical ballet dancers (15°)[17,18].

The plantarflexion ROM (~60°) obtained for volleyball players and physically active subjects (~67°) was slightly higher than that observed for the normal population (~48°)[12,22,23]. This difference may be related to the fact that the values obtained for the normal population are derived from subjects who do not perform any type of systematic physical activity[12,24], whereas the subjects of the present study performed regular physical activity. This fact indicates that sedentary subjects probably do not submit their ankle joints to specific loads, which would increase joint ROM.

The plantarflexion ROM of ballet dancers (~83°) was higher than those observed in the other two groups and is close to values reported for Brazilian classical ballet dancers (~76-84°)[17,18], but lower than those obtained for North American professional ballet dancers (~98°)[24] and elite ballet dancers (~113°)[12]. This difference between elite classical ballet dancers and the ballet dancers studied here is probably related to differences in training (load) level between the two groups, which is higher for elite (professional) dancers compared to the amateur dancers of the present study. According to Hamilton et al.[12], the plantarflexion ROM expected for classical ballet dancers is about 90-100°. Steinberg et al.[25] found a plantarflexion angle among dancers slightly smaller than what is claimed to be desired for classical ballet dancers (86°).

The total ankle joint ROM (i.e., plantarflexion and dorsiflexion ROM) was higher for ballet dancers compared to the other two groups. The same pattern was observed in a study involving 1320 female dancers aged 8 to 16 years and 226 non-dancers of similar age. The results showed a higher ankle joint ROM for dancers compared to non-dancers. However, no change in ankle joint ROM with increasing age was observed among dancers, whereas the ankle joint ROM decreased with age in non-dancers[25].

This functional adaptation and higher total ROM observed for ballet dancers compared to the other two groups is probably related to factors such as: (1) specificity of the different types of tasks of classical ballet and volleyball; (2) duration of activity (the classical ballet group had 8 years of training experience whereas the volleyball group had only 5 years of training experience, Table 1); (3) training frequency (average of five times per week for ballet dancers compared to three times per week for volleyball players), and (4) training program intensity (higher overload of the plantarflexor muscles at shorter muscle length for ballet dancers compared to the greater muscle length for volleyball players).

Many ballet dancers exert marked physical effort to increase their joint ROM in order to improve the amplitude of motion[25]. The increase in ankle flexibility (as demonstrated by the higher plantarflexion ROM) is a basic and necessary condition for correct performance in classical ballet, within the correct technique for this type or modality of dance. This higher flexibility of ballet dancers is related to the adaptation of the ankle joint-surrounding tissues, and may change the force production capacity of both plantar- and dorsiflexor muscles in order to maintain force capacity throughout total ROM, as demonstrated in a recent study[18].

Possible limitations of the present study are the differences in sample size, age and training experience between the three groups since they might interfere with the results obtained by increasing variations in the parameters studied. However, if this were the case, no difference in the results should be observed between groups because of this increased variation. The fact that we observed differences between the three groups studied seems to go against this line of thought. Some of the differences observed in the present investigation when compared to the data of previous studies might be due to the use of different types of equipment. This limitation of the study might reveal some variation in the results among different studies, and therefore caution should be taken when comparing the results.

CONCLUSION

Ballet dancers presented higher plantarflexion and total ankle joint ROM and lower body composition characteristics (body weight and percent body fat) compared to volleyball players and physically active subjects. These differences might be due to variations in functional adaptation, physical demand and years of systematic physical activity (or training regimens) between groups.

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