Kinanthropometric Analysis of the Volume and Muscle Percentage Composition of the Appendicular Segments of Cuban Elite Dancer

EXERCISE AND SPORTS MEDICINE CLINIC

Original Article

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ABSTRACT

Introduction and objective: A ballet dancer with great potential of efficiency for technical transitive movement should show muscle area percentages of body segments in some range of spatial volume that does not classify him /her as an ugly figure. The purpose of this article is to compare the volumetry and percentages on the muscle composition of body segments for elite ballet dancers, with modern-folkloric dancers. Methods: The best dancers of the Cuban National Ballet (BNC), National Dance (DN) and National Folk Group (CFN). The best dancers -ages between 18 and 40 years - were measured following the selection criteria of expert teachers about body shape and technical-artistic performance. An anthropometric protocol of 10 measurements was applied. The equations of geometric model to estimate the total and muscle cross sectional areas of body segments were used, in order to determine the volume and muscle composition. Results and conclusions: The quantitative expression of total cross sectional areas for body segments -in their many relations of similarity and difference- confirmed the empirical statements about a specific criterion of body scenic beauty for both sex dancers from BNC comparing with DN and CFN. Data demonstrated that morphological linearity of an elite dancer is independent from a less potential-except for female dancer from CFN- of efficiency for technical transitive movement.

Keywords: anthropometry, kinanthropometry, body composition, dancer.

INTRODUCTION

Kinanthropometry is a perspective of the physical anthropology epistemologically defined as a set of theoretical suppositions which explain the relations between the morphofunctional structure and the efficiency potential availability of transitive movement of a specialized physical activity– from the practice of the anthropometric technique and the ethnographic field work – which a subject performs in a ontogenic moment[1]. Generally, the scientific published papers on kinanthropometric issues are restricted to quantitative descriptions of indicators related to a meaningful biological temporality from the morphofunctional performance[2,3] and/or a phase of the human ontogeny[4-7].

Countless investigations on the body composition are restricted to the assessment of the holistic expression of the quantities and percentages of the fat and muscle mass in groups of athletes[8-10] and dancers[11-13]. The positive value judgment usually occurs when the assessed individuals record low fat percentages and high muscle percentages[12-14]. However, the explanatory analysis of the pragmatic value is not frequent – the reason for – the absolute quantities of fat and muscle mass in the good/bad prognosis of the body composition. The former limits the cognitive reach of these indicators in the kinathropometric prognosis of a ballet dancer, when its relations with stature and the bone proportionality characteristics of are ignored, according to the esthetic criteria of the art canon.

In the kinanthropometric study of the body composition the distribution of fat and muscle mass for segments of the body extremities are estimated from the calculation of the corresponding transversal areas[15-17]. There is data that similar supposition may be inaccurate due to the kinanthropometric methods of calculation of muscle transversal areas of the segments possibility of underestimating this component in relation to value through computerized axial tomography[18-20]. None of the kinanthropometric methods of estimation of the muscle transversal areas of the appendicular segments[21-23] was developed in a group of ballet dancers and modern and folk dances.

The muscle percentage of the total area of an appendicular segment significantly correlates with the morphofunctional efficiency and potentiality to perform the transitive technical movement of many specialized physical activities[24,25]. From the theoretical suppositions of the kinanthropometry a ballet dancer with great efficiency potential for transitive technical movement should present percentages of muscle transversal areas of the segments in spatial volumetry which does not qualify him/her as ugly in his/her figure (for being obese or out of proportion).

A total transversal area value relates to a physical space tridimensionally occupied by the segment (volumetrically modeled as a cylinder), which positive or negatively determines the morphofunctional and esthetical valuing of the ballet dancers. It is only possible to quantatively measure the spatial volumetry of

a segment applying the elite ballet dancers data classified as thin by ballet teachers who apply in their discriminations the categories of empiric body scenic beauty of art. Quantitative delimitation regardless of the qualitative classification, visual and empiric classification of the ballet coach may cause that ballet dancers with suitable/high percentages of muscle area of a segment are valued as beautiful by the kinanthropometric scientists, when they are labeled as obese (for exceeding their volumetry) and out of proportion (volume that exceeds or is smaller in relation to another segment and/or the whole) in the dance context.

Some kinanthropometric investigations have confirmed the empiric data of the teachers who refer different figures for ballet dancers compared to modern and folk dances ones in the Cuban dance field[7,26,27]. However, which are the volumetry and muscle percentage composition expressions of the body segments of the ballet dancers of each specialty? This is still an unanswered question since kinanthropometry.

The empirical evidence of the dance field mention a greater morphological linearity –longer figure – from the elite ballet dancers compared to the modern and folk dances ones. The kinanthropometric theoretical suppositions point out that the muscle percentages of the body segments should be similar in all kinds of elite dancers due to their positive correlations with the efficiency potential of transitive technical movement. Considering these empirical information, the scientists have proposed the following hypothesis: the elite ballet dancers present similar muscle percentages of the articular segments in smaller body volumes than the modern and folk dances ones. The aim of this investigation is to compare the volumetry and the muscle percentage composition of the body segments of the elite dancers compared to the modern and folk dances.

MATERIALS AND METHODS

Transversal studies have been conducted in Professional Cuban dancers from the National Cuban Ballet (BNC), National Dance (DN) and National Folk Group (CFN). Specialized teachers selected the best female dancers concerning their figure and technical artistic performance of each company at the moment of the measurement (table 1).

The followed procedures were according to the current ethical guidelines of the Culture Ministry of the Cuban Republic for research projects in humans which respect the declaration of Helsinki from 1975. The measured subjects were informed on the study's aims and written consent for the participation in the investigation was obtained.

Table 1. Quantities of ballet dancers studied for each professional Cuban company.

Company	Female (N)	Male (N)
(BNC)National Ballet of Cuba	10	10
(DN)National Dance	13	12
(CFN)National Folk Group	9	9

The anthropometric measurements were performed following the standardized procedures proposed by Lohman *et al.*[28] and Norton and Olds[29]. The anthropometric battery comprised 10 measurements which refer as follows: body mass, stature, circumferences, flexed arm, forearm, medial thigh and maximal leg ,skinfolds: triceps, forearm, medial thigh; medial leg.

The total transversal arm areas (TA-A), forearm (TA-FA), thigh (TA-T) and leg (TA-L) and the muscle transversal area percentages of the arm (MAP-A), forearm (MAP-FA), thigh (MAP-T) and leg (MAP-L) were calculated applying the algorithm of the geometrical model. It adds to the appendicular segments as perfect cylinders which integrate by infinite and successive concentric capes formed by an inner circle of muscle mass (tridimensionally a muscle tube in which the bone mass is considered constant) and an outer and borderline ring of fat mass (the skin mass is depreciated). Euclidean geometry calculates the total area of a transversal area of the segment (extrapolating values for the entire cylinder), as well as the muscle mass and fat mass areas and percentages, using the anthropometric measurements by the non-corrected muscle circumference and skinfold at this somatometric point.

Geometric model of the calculation of the total and muscle transversal areas of the appendicular segments:

RS = (CS/6.28) TAS = 3.14*(RS**2)
RMS = (CS/6.28)-((PS/10)/2) MAS = 3,14*(RMS**2) PMS = (MAS/TAS)*100
RS – Radius of the segment CS – Circumference of the segment
RMS – radial muscle of the segment SFS – skinfold of the segment
TAS – total area of the segment MAS – muscular area of the segment
PMS – percentage of the muscular area of the segment

The statistical analysis was performed with the SPSS 10.5 statistical package for *Windows*. All variables analyzed, by sex and kind of dance, met the normal distribution according to the results of the statistical proof by Kolmogorov-Smirnov. Univariate comparisons of each indicator of the female and male ballet dancers compared to the modern and folk dances ones were performed by the *t* proof for independent samples ($p < 0.05$).

RESULTS

Table 2 presents the means and standard deviations of the data of the kinanthropometric indicators of the three dance companies, for both sexes.

The dancers of the BNC referred significant differences in body mass and stature – with lower values – only when compared to the ones of the CFN. The dancers of the BNC presented statistical similarities in the expression of these body dimensions compared to the other groups. The dancers of the BNC of both sexes presented lower standard deviations and categories for body mass and stature.

The female ballet dancers reported statistically significant total areas – concerning lower values – for upper extremities, concerning the female dancers of the DN and CFN. In the BNC the upper threshold of the category of the thigh and leg total areas was always lower. The female dancers of the BNC presented standard deviation and the lower categories for all

Table 2. Kinanthropometric indicators of Cuban elite ballet dancers of the National Cuban Ballet, National Dance and National Folk Dance.

Indicators	Female			t independent	
	BNC (N = 10)	DN (N = 13)	CFN (N = 9)	*Versus* DN	*Versus* CFN
	Mean ± SD; Min-Max.	Mean ± SD; Min-Max.	Mean ± SD; Min-Max.	Sig	Sig
Body mass (kg)	48.9 ± 2.4; 44.7-52.6	51.4 ± 4.6; 43.2-57.3	56.1 ± 4.2; 47.5-61.5	NS	**
Stature (cm)	161.9 ± 2.5; 157.0-166.5	163.2 ± 5.8; 151.8-173.2	166.1 ± 3.4; 160.9-171.2	NS	**
TA arm (cm^2)	35.4 ± 2.2; 31.0-38.5	40.3 ± 5.0; 33.4-46.3	45.4 ± 5.9; 34.4-54.3	**	**
TA forearm (cm^2)	32.8 ± 1.9; 29.6-35.4	36.2 ± 3.4; 28.8-42.8	40.0 ± 4.0; 34.8-46.3	**	**
TA thigh (cm^2)	184.6 ± 16.0; 157.8-208.6	188.7 ± 20.7; 165.0-248.2	203.6 ± 25.4; 159.6-241.5	NS	NS
TA leg (cm^2)	89.7 ± 7.0; 79.1-100.2	90.2 ± 9.1; 72.0-102.0	96.0 ± 24.2; 78.5-158.3	NS	NS
MAP arm	75.3 ± 6.1; 66.5-83.3	77.5 ± 4.6; 70.6-89.7	69.3 ± 7.0; 59.9-79.4	NS	NS
MAP forearm	86.8 ± 2.3; 83.1-89.8	86.6 ± 2.8; 80.2-91.2	83.3 ± 3.4; 79.1-88.4	NS	**
MAP thigh	81.0 ± 6.2; 69.4-87.7	81.8 ± 5.4; 74.0-90.4	72.0 ± 8.5; 61.2-87.4	NS	**
MAP leg	83.4 ± 6.2; 69.2-88.7	84.5 ± 5.5; 73.1-92.3	80.0 ± 5.4; 72.0-90.3	NS	NS
Indicators	**Male**			**t independent**	
	BNC (N = 10)	**DN (N = 12)**	**CFN (N = 9)**	***Versus* DN**	***Versus* CFN.**
	Mean± SD.; Min-Max.	**Mean ± SD; Min-Max.**	**Mean ± SD; Min-Max.**	**Sig**	**Sig**
Body mass (kg)	67.8 ± 5.3; 61.0-76.2	64.7 ± 6.4; 54.9-73.7	69.9 ± 9.9; 55.9-88.6	NS	NS
Stature (cm)	176.1 ± 3.8; 170.9-183.4	173.8 ± 4.1; 165.1-180.0	175.8 ± 5.7; 165.5-183.2	NS	NS
TA arm (cm^2)	62.7 ± 5.9; 55.4-71.7	63.3 ± 7.7; 53.3-77.9	70.8 ± 13.8; 48.5-96.0	NS	NS
A.T. antebraço (cm^2)	52.8 ± 4.8; 44.6-60.2	54.6 ± 7.4; 43.2-66.2	58.7 ± 8.7; 42.5-71.1	NS	NS
TA thigh (cm^2)	227.3 ± 21.5; 191.0-256.6	219.7 ± 20.7; 180.4-252.1	230.8 ± 31.8; 186.6-300.3	NS	NS
TA leg (cm^2)	113.2 ± 11.5; 97.1-127.4	100.2 ± 10.3; 81.7-120.3	107.3 ± 13.5; 78.5-123.0	**	NS
MAP arm	86.8 ± 3.2; 80.0-89.7	87.1 ± 3.4; 80.9-91.6	84.5 ± 5.2; 76.0-92.6	NS	NS
MAP forearm	88.2 ± 1.7; 84.7-90.6	89.4 ± 1.4; 86.9-91.6	89.3 ± 2.3; 85.5-93.0	NS	NS
MAP thigh	90.7 ± 2.6; 85.4-94.5	91.9 ± 3.4; 83.0-95.3	88.8 ± 4.8; 82.0-95.5	NS	NS
MAP leg	88.2 ± 4.6; 78.0-93.4	91.0 ± 2.8; 85.5-94.1	87.8 ± 5.5; 80.5-94.6	NS	NS

**p < 0.05. N – National; C – Cuba; TA. – total transversal area; MAP – muscular area percentage ; SD – standard deviation; Max. – Maximum; Min. – Minimum

total transversal areas of the segments. The total transversal areas of the segments of the dancers of the BNC were only different – concerning higher values – in the comparison of the TA-L with the DN. The dancers of the BNC presented lower categories for the TA-FA than the DN and the intervals of lower values for all total areas compared to the CFN group. The TA-L recorded the lower threshold of highest value – in more than 15.0cm – for the dancers of the BNC.

The dancers of the BNC and DN presented statistical similarities – in intervals of similar values – for all percentages of the muscular area of the segments. Statistically significant differences have been obtained – with higher values – for the MAP-A and MAP-T of the dancers of the CFN in the comparisons with the BNC; both dimensions showed higher category in the dancers of the CFN. Statistical similarities have been found among all muscular percentages of the segments of the dancers of the BNC, compared to the other specialties. The dancers of the DN expressed a lower MAP-L – in over 7.0% – higher than the BNC group.

DISCUSSION

The DN and CFN groups of both sexes recorded extremely low homogeneity for body mass. The empirical evidence of the ballet field minimizes the body mass absolute value – the teachers never weight their pupils – when cognitively supports the qualitative appreciation of obesity-thinness in multiple characteristics not exclusively connected to a quantitative result of dimension[30]. Consequently, the differences obtained only express the higher possibility of occupying a smaller physical space for the elite dancer of the BNC compared to the others. These results do not agree with any obesity-thinness differential diagnosis – based on the tendency to an absolute body mass quantity – according to the kind of dancer.

Stature of most of the ballet dancers was within the interval (160.0-164.0cm), not completely limiting the joining the BNC category (157.0-171.0cm)[1]. The minimum (151.8cm) and maximum stature thresholds (173.2cm) in the DN group referred to an inapt elite female dancer – for being considered too short and too tall, respectively – to professionally perform in the BNC. Lower homogeneity for stature in the DN group is the expression of a differential criterion of qualitative evaluation of the dimension among the dance specialties (personal communication of Miguel Iglesias, DN director). Therefore, it is counterproductive to relate the great stature variability of the DN group with a lower artistic technical level – versus the same activity or group BNC – according to the kinanthropometric theoretical suppositions which positively relate body homogeneity and competitive success[2].

All the female dances of the CFN were within the stature category of the BNC, but the comparisons between both groups were different. Such fact is due to the similar homogeneity level for the dimension of the two specialties in significantly different numeric intervals. The data show that an elite dancer of the CFN will probably be taller than one of the BNC; such fact positively corresponds to the empirical and historic evidence

that there are not many tall ballet dancers valued as elite in the BNC.

All ballet dancers have registered in the stature category of the BNC[1]: 170.0-183.0cm, the difference between some elite dancers of the DN and CFN which presented shorter stature – in over 4.0cm – to this minimum acceptance level. Similar results expressed higher homogeneity for the BNC group, which corroborated the differentiated artists' appreciation of the dimension which the modern and folk dances teachers performed.

Higher hypertrophy of the upper extremities musculature was observed for the components of the DN and CFN, which agrees with the empirical evidence which refer higher morphological linearity for the female dancers of the BNC. The intense work of the muscles of the upper extremities in classical ballet is not characteristic of the technical training, while the modern and folk dances practitioners regularly perform intense physical activity in this musculature, which is the work on the floor. The MAP-A and MAP-FR comparisons in the female dancers of the BNC and DN showed similar levels of efficiency potentiality of the transitive movement of the upper extremity.

The lower MAP-FA of the female dancers of the CFN – significantly different compared to the BNC – showed lower efficiency potentiality of the transitive movement of a volumetrically bigger segment compared to the BNC.

The BNC, DN and CFN dancers did not show statistically significant differences in the comparisons of all kinanthropometric indicators of the upper extremities. These results presented a morphofunctional very similar among the elite dancers of the BNC and DN, since the intervals of the total transversal areas of the upper extremities were also similar. However, some dancers of the CFN present a total arm area – volumetry – extremely bigger than the ones of the BNC group. Such fact presents great empirical value, since these subjects of the CFN would be extremely cut out to classical ballet, but are elite in folk dance, though.

In the female professional dancers the statistic similarities of most of the ineanthropometric indicators of the thigh and leg– except for MAP-L in the comparison between BNC and CFN – did not minimize the homogeneity differences marked between group BNC versus the other specialties. The female dancers of the BNC showed the smaller category for the TA-T in a numerical scale which reflected more reduced spatial volume, since the values of both quantities of the TA-T were lower than the recorded ones in DN and CFN.

The data reflected not much volumetrically bold lower extremities for the majority of the female modern and folk dancers, but some components of the DN and CFN with TA-T and TA-L with values extraordinarily higher than the pro-medium and the lower thresholds of the female dancers of the BNC were found. This kind of elite modern and folk dancer supports the empirical data of the dance field concerning higher morphological linearity for the dancer of the BNC. Higher body volumes in the lower extremities of these dancers of the DN and CFN occupy excessive physical space for the thinness ballet canons, which would probably classify them as obese and would negatively reflect on the possibility to dance in public places.

The similar expressions of the MAP-T and MAP-L for the DN and BNC groups demonstrated that the higher morphological linearity of the lower extremities of the ballet dancer depends only on the lower volumetry associated to thinness which was historically defined in the art esthetic canon; such fact was not found for the comparisons of the dancers of the BNC and the CFN. Both types of elite dancers of the BNC and DN present equal potentialities of transitive technical movement efficiency, which is opposite to the empirical statements of some teachers concerning the higher level of physical activity work capacity of the Cuban ballet dancer. The lower MAP-T values for the female ballet dancers of the CFN positively associate to the empirical statements which refer to a fat lower extremity (higher volume associated to a differential criterion of morphological linearity) which is lenient, slow, with little elevation and jumping capacity for the folk dancer compared to the BNC.

The male ballet dancers of the DN recorded different TA-T and TA-L – with values lower than the BNC group. An inverted cone visually holistic shape was configured for the lower extremities of the DN dancer, reflecting a proportional volumetric distribution pattern of the thigh and calf significantly different to the more cylindrical/aligned conformation of the lower extremities of the BNC components.

The ballet and folk dancers presented statistic similarities for all kinanthropometric indicators of the lower extremities. Individuals with very different values (higher TA-T and lower TA-L in the folk members) in the total areas were found between the BCN and CFN groups, which presented the existence of specific shapes, volumetric and proportionally, of the lower extremities for each specialty. All ballet dancers recorded similar muscular percentages, which demonstrated that the differences of the empirical categorizations of greater morphological linearity for the ballet dancer only sustain in the indistinct spatial distribution of the absolute quantities of muscular mass in the appendicular segments.

CONCLUSIONS

The quantitative evidence discarded the work hypothesis only for the female ballet dancers of the CFN, since no similarities were recorded in the percentages of the muscular areas of all appendicular segments. The quantitative expression of the total areas by segment, in their multiple relations of similarity and difference, corroborate the empirical statements which refer to a differential criterion of body scenic beauty, as a elongated figure or greater morphological linearity, for the ballet dancers of both sexes of the BNC compared to the DN and CFN. The data demonstrated that the morphological linearity of an elite dancer is not dependant on the expression of a lower potentiality – except for the ballet dancer of the CFN – concerning the transitive technical movement.

All authors have declared there is not any potential conflict of interests concerning this article.

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