Original article (short paper)

Neurocognitive aspects of body size estimation – A study of contemporary dancers

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Abstract — Dancers use multiple forms of body language when performing their functions in the contemporary dance scene. Some neurocognitive aspects are involved in dance, and we highlight the aspect of body image, in particular, the dimensional aspect of the body perception. The aim of this study is to analyze the perceptual aspect of body image (body size estimation) and its possible association with the motor aspect (dynamic balance) involved in the practice of dance, comparing contemporary dancers with physically active and inactive individuals. The sample consisted of 48 subjects divided into four groups: 1) Professional Group (PG); 2) Dance Student Group (SG); 3) Physically Active Group (AG); and 4) Physically Inactive Group (IG). Two tests were used: the Image Marking Procedure (body size estimation) and the Star Excursion Balance Test (dynamic balance). Was observed that dancing and exercising contribute to a proper body size estimation, but can not be considered the only determining factor. Although dancers have higher ability in the motor test (dynamic balance), no direct relation to the perception of body size was observed, leading us to conclude it is a skill task/dependent acquired by repeating and training. In this study, we found a statistical significant association between educational level and body size estimation. The study opens new horizons in relation to the understanding of factors involved in the construction of the body size estimation.

Keywords: dance, body scheme, cognition, balance

Introduction

Contemporary dance involves reflection and research around the body and its organization. Tourinho and Silva[1] consider all expressive possibilities as material for dance, making room for different possibilities of acting and the chance for interaction with any knowledge area. Currently, it is rare to observe a dancing body built with a specific technique, because there are many body esthetics present in the dance scene, showing such a complex movement organization, presenting technical and esthetic specificities that show an investigative character leads to new body maps of movement[2]. All possibilities expressed by the body are used to compose the role of dancers in the scene of contemporary dance and therefore, different body practices should be included in their training. Thus, in addition to dance, other non-artistic body practices could also contribute to knowledge about oneself, expanding body qualities.

Dance involves movement integration, body balance, and aspects related to postural control. Information on balance is important in dancers because they are considered postural control models[3]. Dance training improves sensorimotor functions, static and dynamic balance, which shifts the sensory motor predominance from vision to proprioception. Therefore, skilled dancers should have a more accurate assessment based on proprioceptive information, and rely more on proprioception than on vision[4].

In addition to being one of the oldest forms of human expression, dance is a highly complex motor activity that demands visuospatial, kinesthetic, and auditory skills, among others. In his study, Wachowicz[5] discusses cognitive abilities introduced in the dance context, such as attention, perception, and memory. Further, Beausoleiland Le Baron[6] argue that dance and physical activity in general have also shown improvement in brain function because they facilitate learning, stimulate the growth and repair of neurons and inter-synaptic connections, and result in improved general cognitive ability.

Addressing body perception also considers the mental construction of one's own body, which is given by the fusion of subjective impressions and multimodal afferent information. The subjective/attitudinal aspect is related to the (dis) satisfaction with one's own body (body image), and the perceptual aspect examined in this study is based upon the ability to recognize the size, shape, and location of the body as a whole and of its segments (body size estimation). Information regarding body dimension serves to guide the movement of the body through space.

Dancers use various motor and cognitive skills in their professional practice, such as dynamic and static balance, motor imagery, learning, memory, attention, and reasoning. In the present study, all motor and cognitive skills involved in the performance of dancers working at the contemporary dance scene were addressed. Thus, we questioned if these dancers build their body size estimation by the practice of dance, and if such dimensional perception is more accurate than that of the general population.

Therefore, the aim of this study is to answer the following question: Do dancers build a more accurate body size perception because of their dance practice?

Method

The project was approved by the Ethics Committee of the São Judas Tadeu University under numbers CAAE:

22190513.0.0000.0089. In accordance with ethical guidelines, all participants were provided with written informed consent.

The entire sample consisted of 48 individuals (34 female and 14 male). Participants were further distributed into the following groups: Professional group: 12 professional dancers of both sexes aged between 22 and 38 years (29.9±4.79), with 20 years of practice on average, and working in professional contemporary dance companies located in São Paulo. Dance Student Group: 14 students of both sexes aged between 18 and 45 years (26.4±7.6), attending the last year of advanced training course in contemporary dance of the Centro de Dança de Santo André. Active group: 12 participants of both sexes aged between 18 and 39 years (26.2±8.1), practitioners of different types of body activities, not including dance. Inactive group: 10 participants of both sexes aged between 18 and 51 years (33.9±10.5).

The Professional Group (PG) included seven female and five male participants, of which 66% have completed, or are currently enrolled in higher education. These individuals work in professional dance companies in the city of São Paulo, with a daily workload of six hours involving body practices, such as classical ballet, yoga, techniques of modern dance, and somatic education. The Dance Student Group (SG) included 11 female and three male participants. Fifty percent of them have higher education. They were invited to participate in this study since they were attending their last year of training in contemporary dance at the Centro de Dança de Santo André. The course comprises theoretical and practical disciplines (classical ballet, modern dance, contemporary dance techniques, dance psychology, didactics, contact and improvisation, history of dance, and creation process) with a 2300-hour load distributed over three years.

The Active Group (AG) included nine female and three male participants, of which 66% have completed, or are currently enrolled in higher education. They were invited to participate through friends and family, and were characterized as active by application of a questionnaire to evaluate the history of systematic practice of different sports and physical activities, such as volleyball, Surf, capoeira, swimming, basketball, indoor soccer, weight training, walking, running, athletics, karate, cycling, and jiu-jitsu.

The Inactive Group (IG) included seven female and three male participants, of which 40% have a college degree and have never had any college degree and have never had any regular involvement on physical activity.

Image Marking Procedure (IMP)

The Image Marking Procedure (IMP) was initially described by Askevold[7] and adapted by Thurm[8]. It is a projective test in which participants are tagged with labels on the following body parts: right and left acromioclavicular joint (shoulder), right and left waist curves, and greater trochanters of the right/left femur (hip). This procedure ensures that all subjects are tagged in the same places.

Participants remained in a standing position in front of a white wall. They were verbally instructed during the blindfold test, specifically that they had to imagine the wall as a mirror in which they would see themselves.

The first anatomical point evaluated was the top of the head, and after the researcher's touch, the participant projected the point by touching the wall with his/her index finger. Next, the same procedure was used for the selected points. The points were stimulated in the following order: 1) highest point of the head; 2) right acromioclavicular joint and left acromioclavicular joint; 3) right and left waist curve; 4) right greater trochanter and left greater trochanter (Figure 1). At this point, the evaluator identified the points on the wall with a smaller label. This procedure was performed three times consecutively and in sequence.

Finally, the participant was placed next to the wall. With the use of an L-shape ruler placed at a 90-degree angle relative to the longitudinal axis of the body, the actual size projections were marked with a larger label (Figure 2). The points marked on the wall and the participant identifications were photographed with a digital camera for later analysis.

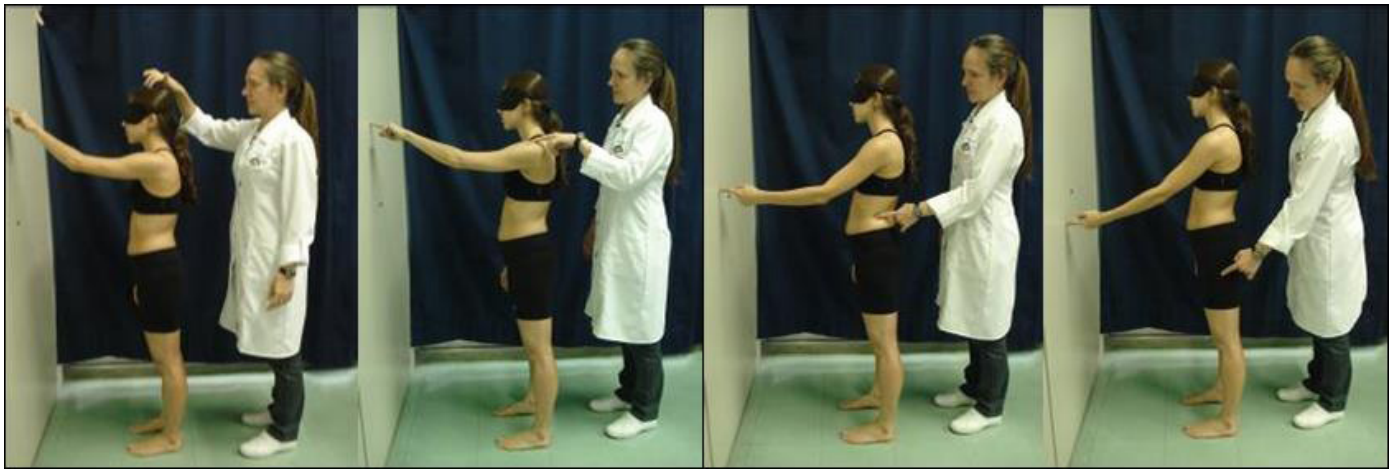

Figure 1. Image Marking Procedure illustration.

Source: Thurm[9] (2012, p. 17).

Figure 2. Actual size projection using the L-shape ruler.
Source: Thurm[9] (2012, p. 17).

The evaluated measurements were the distances between the points marked by the subjects (perceived size) and by the evaluator (actual size). On the horizontal line, the measurements represent body width (distance between the right and left side).

Therefore, the test allowed the evaluation of the relationship between the perceived size (PS) and the actual size (AS). Body Perception Index (BPI) was calculated based upon these values using the following formula:

$$BPI = PS/AS \times 100\ (\%)$$

Additionally, the general BPI (BPIg), determined by the average BPI of the head height, shoulder width, waist and trochanter was calculated. These were the parameters used for quantitative analysis in this study.

After the BPI calculation, participants were classified as hypo-schematic (an underestimation of actual body size)if they had BPI values of less than 99.4%. Those with values equal to or greater than 99.4% and less than or equal to 112.3% were classified with adequate body size estimation, and those with values greater than 112.3% as hyper-schematic (an over estimation of their own body size)[10].

Star Excursion Balance Test

An eight-rayed star was built with masking tape on paper (anterior, anterolateral, lateral, posterolateral, posterior, posteromedial, medial, and anteromedial), and each ray contained a tape measure. The participant remained in the anatomical position, hands on hips, standing and maintaining balance on one leg in the center of the star while the opposite leg hit the eight-rayed star with the hallux in a clockwise direction. The evaluator recorded the distance achieved with each touch toward the end point reached on the tape measure.

The stance leg could be flexed and the trunk could be tilted, if the stance leg was not compromised. The procedure was repeated three times to minimize the chance of errors, followed by three-minute pauses. Then, the procedure was repeated with the left leg in a counterclockwise direction[11].

Excursion distances were normalized to the participant's leg length for further analysis. Normalization was performed by dividing each excursion distance by the participant's leg length, and then by multiplying by 100.

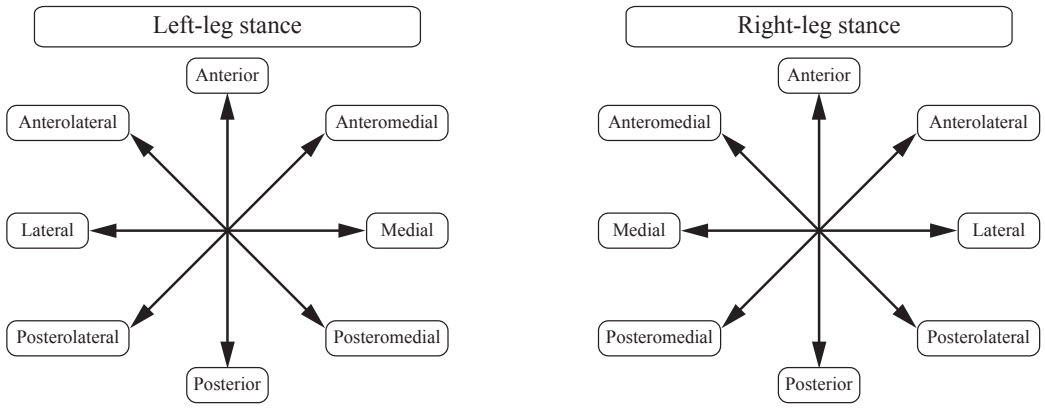

Figure 3. Reaching direction for the Star Excursion Balance Test.

Data analysis

The one-way ANOVA (analysis of variance) was used to compare the general BPI between groups; the ANOVA with repeated measures was used to compare the BPI of height, shoulder, waist, hip, the number of hits, and the displacement reached by each foot for each ray of the star: posteromedial, medial and anteromedial per group. The chi-square test was used to assess the association between educational level and classification of the general BPI. The significance level was set at 5% using the SPSS statistical software (version 21).

Results

Body size estimation

The groups were analyzed regarding the perception of general body size estimation evaluated from the calculation of Body Perception Index (BPI). Subjects were classified according to the criteria suggested by Segheto[12]: BPI less than 99.4% was classified as hypo-schematic, values equal to or greater than 99.4% and less than or equal to 112.3% were classified as adequate, and values greater than 112.3% were considered hyper-schematic. We observed that the PG (112.0±16.5%), SG (108.1±11.9%) and the AG (108.3±11.9%) had adequate perception, while the IG (117.9±16.9%) was classified as hyper-schematic (Figure 4).

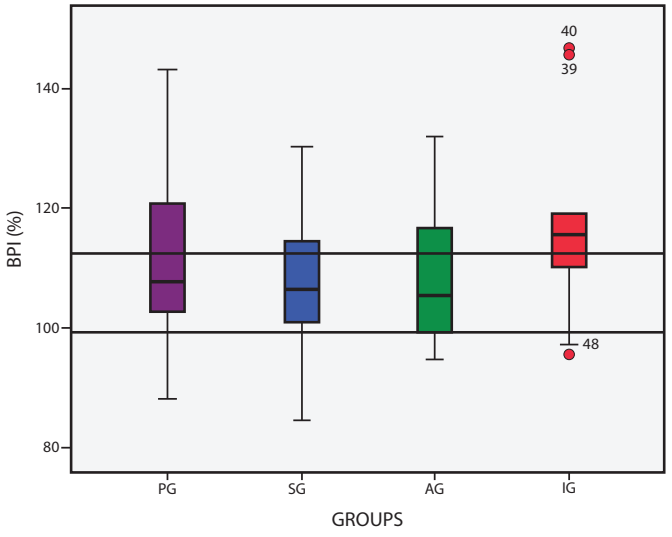

Figure 4. Distribution of participants of four groups (PG= professional group, SG= dance student group, AG= active group and IG = inactive group) according to general BPI.

Perception of body size by segments

By analyzing the perception of height, shoulder width, waist and hip, we observed that the most overestimated region was the waist (F=33.23; p=0.01) in all groups (PG=129.2±31.8%; SG=123.9±20.5%; AG=124.9±21.7%; and IG=137.7±22.2%). However, there was no statistically significant difference between groups (Figure 5).

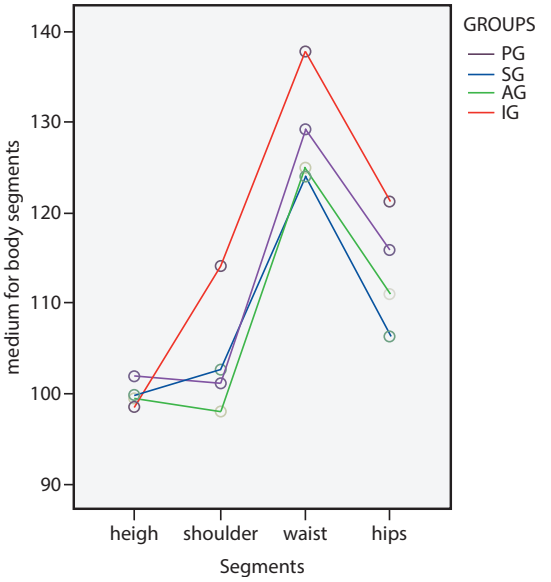

Figure 5. BPI by body segments (height, shoulder, waist and hip) related to groups (PG = professional group, SG = dance student group, AG = active group and IG = inactive group).

Dynamic balance

For the analysis of this variable, the posteromedial, medial, and anteromedial positions in the Star Excursion Balance Test were used because they were considered the most difficult positions according to the averages obtained across the four groups. A comparison of the groups showed that the PG reached greater distances in the posteromedial and medial rays compared to the other groups (F = 16.88, p = 0.01). When comparing the right side to the left side, we observed that groups behaved similarly (Figures 6 and 7).

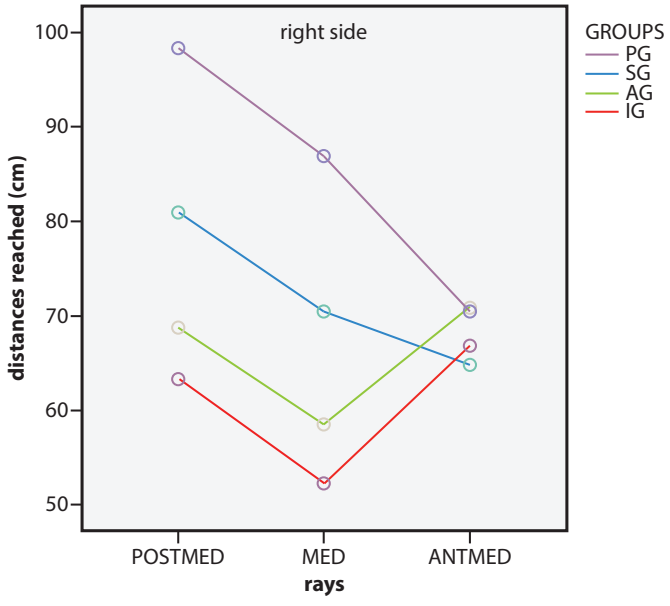

Figure 6. Distances (in centimeters) reached by ray (posteromedial, medial, and anteromedial) of the groups (PG = professional group, SG = dance student group, AG = active group and IG = inactive group) for the right side.

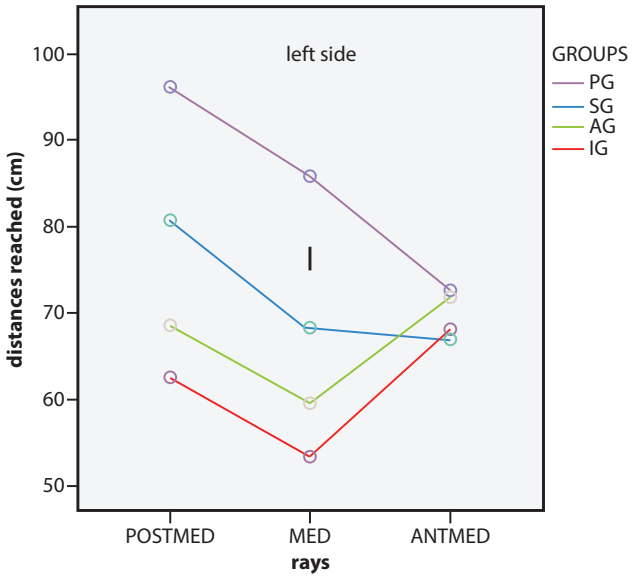

Figure 7. Distances (in centimeters) reached by ray (posteromedial, medial, and anteromedial) of the groups (PG = professional group, SG = dance student group, AG = active group and IG = inactive group) for the left side.

Educational level

The data obtained by analyzing the relationship between educational level and all other variables using the chi-square statistical test showed a statistically significant association only between educational level and the classification of body size estimation (Table 1).

Table 1. Chi-square test (educational level and classification of general BPI)

Educational level	Classification of general BPI		TOTAL
	ADEQUATE	*INADEQUATE	
Higher	13	14	27
High school	4	17	21
TOTAL	17	31	48

[X^2.(1)= 4.37; p=0.03]

*hypo and hyper-schematic

Discussion

The aim of this study is to analyze the perceptual aspect of body image (body size estimation) and its possible association with the motor aspect (dynamic balance) involved in the practice of dance, comparing contemporary dancers with physically active and inactive individuals.

The initial hypothesis of this study was that by executing very complex movements and requiring the most accurate of body size estimation possible, all dancers would present Body Perception Index (BPI) very close to 100%.

However, the hypothesis was not confirmed. The data obtained in the projective test of body size design showed that participants of GP, SG, and AG showed adequate perception of body size according to the classification suggested by Segheto[10], with no difference between groups regarding BPI values. The physically inactive group (IG) was hyper-schematic, i.e., they overestimated their body dimension.

Both dance and the practice of physical activity contribute to the construction of adequate body size estimation, but are not considered to be determining factors. Gardner[13] indicates additional aspects are involved in body size estimation, including value judgments, eating disorders, mood states, depression, age, sexual abuse, media influence, menstrual cycle, and interoceptive stimuli.

Data of the present study led to a reflection on the other aspects involved in body size estimation. Even though the literature highlights the importance of proprioceptive stimuli for building one's perception of body dimension, there is no unanimity pointing to body practices as key factors in the construction of such perception[13-15].

In particular, the essay produced by Mullis[14] discusses the contribution of attitudinal and perceptual aspects of body image, and the nature of their interaction in clarifying how the body can be transformed into an esthetically expressive medium developed by the dancer. The work also states that in dance practice, the perception of body dimensionis used to consciously develop body maps with the ability to form and maintain new motor programs by integrating different types of neural information. This idea was also revived and experimentally verified by Damásio[16] who stated that neural maps of body states are useful to manage the body.

In a recent study by Tsakiris et al.[15], body practice is not mentioned as a possible strategy to develop the perception of body size estimation, and interoceptive stimuli (viscerceptive) are indicated as one of the components for constructing the perception of body dimension. The results of the study showed the trend toward adequate self-perception in individuals with high inter-sensitivity from the self-perception of heart rate.

Based upon the aforementioned studies, we observed that body size estimation depends upon the interaction of different physical and subjective factors. Thus, the practice of body activities can be considered as a factor for constructing the perception of body dimension.

By analyzing the body size estimations of different body parts (height, shoulder, waist, and hip), interestingly, all participants showed a distortion of perception in the waist area. This can be attributed to the fact that participants are predominantly female in all groups. Most studies on body image have focused upon women, and have shown a greater dissatisfaction with body dimension in the female gender[17,18]. Moreover, a study by Thurm[9] found that the waist region is most often overestimated in patients with eating disorders, such as anorexia and bulimia, which afflicts mostly women.

Particularly in the group of dancers, a possible explanation for having a distorted perception of the waist region can be attributed to the same factor because studies show the frequent occurrence of dissatisfaction with one's own body in dancers.

As these professionals have a high level of demand for physical performance and body esthetics, they are included in a risk group for developing eating disorder behavior[19-21].

Regarding the motor analysis (dynamic balance), the results confirmed that PG and SG were able to reach greater distances with one-foot support in different directions compared to the AG and IG. Therefore, dancers have greater development of dynamic balance compared to practitioners of other body activities and physically inactive individuals. This phenomenon was also observed in studies comparing the evaluation of static and dynamic balance between dancers and non-dancers[3,4,22]

In particular, Golomer et al.[22] analyzed the interaction between visual restriction and somatosensory disorders on one-leg balance control for dancers and non-dancers. They found that dancers have a superior dynamic balance capacity and less oscillation on one-leg control when compared to individuals who do not practice dance.

Data found in the literature demonstrated a greater ability of dynamic balance in dancers. Thus, the aim of the present study was to evaluate the dynamic balance by using it as a motor test to investigate a relationship with the body size estimation. For balance, proprioceptive information is used to maintain posture and accurate information about the body dimension and its relation to surrounding space is necessary.

Our data did not show a significant relationship between body size estimation and dynamic balance. However, dancers stood out in this test, probably because this group's ability of reaching greater distances on one foot is a skill task/dependent acquired through the specificity of training and repetition of movement.

During the data analysis process, when analyzing and classifying the body perception index (BPI), we observed that individuals with higher education had an adequate perception of body size and that this was particularly evident in SG. Therefore, we divided all participants of the study into two groups: those with higher education and those without higher education, and these were categorized as having adequate or inadequate body size estimation (regardless of hyper- or hypo-schematic). In the statistical analysis with a non parametric test, an association was found between educational level and classification of body size perception.

From the results, it is not possible to affirm that those with higher education perceive their body dimension properly as half of the participants in this group perceived their dimension adequately and the other half inadequately. However, interestingly, the results point to inadequate perceptions among participants with lower education.

In the literature, no specific studies for the discussion of this data were found. However, the aim of the review by Nóbrega[23] was to present a new concept of perception involving arts and science from a theoretical study based upon the work of Merleau-Ponty phenomenology. This complex phenomenological study included many notes regarding perception. Specifically, in the sense that in the broadest conception of human experience, the understanding of oneself is resized in the process of knowledge through body movement, making the cognition inseparable from the body, because it is an interpretation that emerges from the relationship between the self and the world in the capacities of understanding.

Thus, movement is culturally incorporated by articulating new ways of understanding knowledge. It seems the body dimension perception phenomenon is much broader than the simple interaction of neural information within the body.

Damásio´s[16] work entitled *E o cérebro criou o homem,* is worth being highlighted because it elucidates this data, specifically when presenting the topic of map and image generation from body. It states that the distinguishing feature of our brain is its impressive ability to create maps. Information in this mapping can be used unconsciously to effectively guide motor behavior, because when the brain creates maps, it is also creating images that, according to the author, are the main circulating medium of the mind. Consciousness allows us to experience maps as images by manipulating them and applying reasoning, which is a component of cognition that forms learning.

Similarly, our study has detected this association with 'educational level", when in fact the main character to be analyzed is the reasoning ability and other cognitive aspects (perception, learning, memory, attention, vigilance, and problem solving).

In fact, corporeality and cognition, brain and body have a closer relationship. The association between educational level and body size estimation accuracies was identified in this study, even though it was not part of our prior objectives. However, the importance of this result requires further investigation to clarify this relationship.

Conclusion

Professional dancers demonstrated advanced skills in certain abilities involving balance, coordination, rhythm, and somatosensory functions. Although these professionals use their bodies as forms of artistic expression and have full control over them, they are not immune to influences that determine body size estimation.

This study found that dancers apparently do not build a perception of body dimension developed by the practice of dance, in spite of their greater ability presented on the motor test (dynamic balance). No direct relationship was observed between body size estimation and motor performance, which led to the conclusion that this is a task skill task/dependent acquired through the specificity of movement learned.

This study opened new horizons with regard to understanding the construction of perception of body size. An association between educational level and body size estimation was found, and there should be further investigation to clarify this relationship.

In fact, the art of dance is a multidisciplinary area that can be investigated by different perspectives in various fields such as the social, human, exact, and health sciences. A wide dialogue between these areas is necessary to expand the vast knowledge on dance within in the art scene in order to answer questions like those raised by this study.

References

1. Tourinho LL, Silva EL. Estudo do movimento e a preparação técnica e artística o intérprete de dança contemporânea. Arte Filosofia. 2006;1: 125-33.

2. Nunes SM. O Criador-intérprete na Dança Contemporânea. Revista Nupeart. 2002;1: 83-96.
3. Costa MSS, Ferreira AS, Felicio LR. Equilíbrio estático e dinâmico em bailarinos: revisão da literatura. Fisioter. Pesqui. 2013; 20(3): 299-305.
4. Bläsing B, Calvo-Merino B, Cross ES, Jola C, Honisch J, Stevens CJ. Neurocognitive motor in dance perception and performance. Acta Psychol**.** 2012;139: 300-308.
5. Wachowicz F. Cognição coreográfica: investigações sobre a habilidade da memória do movimento. Salvador. Tese. [Doutorado em Artes Cênicas]– Universidade Federal da Bahia; 2009.
6. Beausoleil E, Lebaron M. What moves us: dance and neuroscience implications for conflict approaches. Conflict Resolution Quarterly.2014;31 (2): 133-158.
7. Askevold F. Measuring body image. PsycotherPsychosom.1975; 26: 71-77.
8. ThurmBE. Efeitos da dor crônica em atletas de alto rendimento em relação ao esquema corporal, agilidade psicomotora e estados de humor. São Paulo. Dissertação [Mestrado em Educação Física] – Faculdade de Educação Física da Universidade São Judas Tadeu; 2010.
9. Thurm BE. Perfil da percepção corporal e a insatisfação corporal em mulheres com transtornos alimentares: uma proposta de intervenção corporal. São Paulo. Tese. [Doutorado em Educação Física]– Faculdade de Educação Física da Universidade São Judas Tadeu; 2012.
10. Segheto KJ, Pereira ES, Gama, EF. Body scheme: Theoretical considerations. Fiep Bulletin. v. 80.(2010).
11. Gribble PA, Hertel J. Considerations for Normalizing Measures of the Star Excursion Balance Test. Measurement in Physical Education and Exercise Science.2003;7 (2): 89-100.
12. Segheto, W; Segheto, KJ; Silva, CB; Gama, EF. Esquema corporal e nível de atividade em adultos jovens universitários. Revista Brasileira de Ciência e Movimento. 2011; 19 (3): 29-36.
13. Gardner RM. What Affects Body Size Estimation? The Role of Eating Disorders, Obesity, Weight Loss, Hunger, Restrained Eating, Mood, Depression, Sexual Abuse, Menstrual Cycle, Media Influences, and Gender. CurrPsychiatryRev. 2011;7 (2): 1-8.
14. Mullis EC. The Image of the Performing Body. J Aesthet Educ. 2008;42 (4): 62-77.
15. Tsakiris M, Tajadura-Jiménez A, Constantini M. Just a heartbeat away from one's body: interoceptive sensitivity predicts malleability of body-representations. Proceedings of the Royal Society B. 2011.
16. Damásio AR. E o cérebro criou o homem. São Paulo: Companhia das Letras.2011.
17. Damasceno VO, Vianna VRA, Vianna JM, Lacio M, Lima JRP, Novaes JS Imagem corporal e corpo ideal. RBCM. 2006;14(1): 87-96.
18. Alves, D, Pinto M, Alves S, Mota A, Leirós V. Cultura e Imagem Corporal. Motricidade.2009; 5(1):1-20.
19. Ribeiro LG, Veiga GV. Imagem Corporal e Comportamentos de Risco para Transtornos Alimentares em Bailarinos Profissionais. Rev. Bras Med Esporte. 2010;16 (2): 99-102.
20. Hass AN, Garcia ACD, Bertoletti J. Imagem Corporal e Bailarinas Profissionais. Rev. Bras Med Esporte. 2010;16(3): 182-185.
21. Rivaldi, C, Vannacci A, Bolognesi E, Mancini S, Faravelli C, Ricca V. Gender role, eating disorder symptoms, and body image concern in ballet dancers. J. Psychosom. Res. 2006; 61(4): 629-636.
22. Golomer E, Mbongo F, Toussaint Y, Cadiou M, Israel I. Right hemisphere in visual regulation of complex equilibrium: the female ballet dancers' experience. Neurol Res. 2010; 32(34): 409-415.
23. Nóbrega TP. Corpo, percepção e conhecimento em Merleau-Ponty. Estud. psicol. 2008; 13(2): 141-148.

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