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Assessment of the level of static and dynamic balance in healthy people, practicing selected Latin American dances

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Purpose: The balance, known as the ability to independently maintain the body in a certain position and return to the starting position, can be divided into static and dynamic balances. Social Latin American dances (salsa, bachata) require dancers to do a characteristic figure, however, they are not trained as intensively as dancing sports. The aim of the study was to assess the static and dynamic balances of dancers, who are regularly dancing those selected Latin American dances, by comparison with those who do not. *Methods*: The study was conducted among 34 dancers from a Krakow Dancing School and, 37 students of the Jagiellonian University, aged 21–35. A SIGMA balance platform was used to measure static and, the Y-Balance Test platform to assess dynamic balance. The Student's *T*-test, Mann–Whitney *U*-test and Spearman's rank correlation coefficient were used in statistical analysis. *Results*: There were neither significant differences between right and left lower limbs of dancers, nor between values of tilts on the YBT platform in both investigated groups. Non-dancers, however, showed a slightly higher positive correlation between the deviations in the sagittal and frontal planes and the surface area, as well as between the path length and the surface area on the SIGMA platform when compared to dancers. *Conclusions*: The level of dynamic and static balances of dancing people is similar, when compared to non-dancers. The influence of practicing Latin American dances on the sense of balance require further studies.

Key words: *static balance, dynamic balance, salsa, bachata, dancers*

1. Introduction

The ability to maintain balance is defined as the ability to independently maintain a position and return to the starting point. After changing it by maintaining the applied force of gravity (COM – center of mass) in the surface area of the supporting plane determined by the foot contour. Balance depends on the location of the foot's center of pressure (COP), the composition, and the speed at which these points move. Generally, maintaining balance consists of its constant loss and recovery [18], [27].

The human body balance can be divided into static (the body does not change the support point) and dynamic (the body support point changes) [14]. Three systems are primarily responsible for maintaining balance: vision, vestibular and proprioceptive. The first two are responsible for receiving information about the position of the head in space. The third one collects and analyzes information about the position of the whole body in space. These systems are intensively engaged in various physical activities, especially in all forms of dance [11], [15].

Dancing can be defined as a rhythmic movement performed with music. It has been around for centuries, performed primarily for social and emotional functions to communicate or to express emotions and beliefs [2], [11]. Dancing training regularly influences the development of strength, endurance, coordination

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and spatial orientation. It also improves human flexibility and agility. It has a positive effect on body awareness, self-confidence and imagination. In addition, it teaches how to react quickly to the of changing external conditions that take place due to dynamic position changes [12], [29]. It also helps to improve the work of internal organs and systems (heartbeat, cardiovascular function, breathing rate, oxygenation of the body, intestinal peristaltic movements and the muscle tone) in a way that depends on the pace and quality of movement [4]. Regular dance training practiced by the elderly improves their static balance and reduces the risk of falls. Studies conducted by Wallmann et al. on women over 50 have shown that systematic jazz dancing also improves the balance [28]. According to research carried out among professional ballet dancers, ballet dance not only improves balance, but also automates its control due to the more developed perception and motor skills. Therefore, maintaining balance is less dependent on visual information [17], [26].

Latin American dances are a group of ballroom dances. They are characterized by high expression of emotions, feelings and closeness, often also significant dynamics of performed movements. A very characteristic feature of this group is the isolation of the upper body from, the lower body and the sensual movements of the dancers. They are divided into tournament and utility dances. The tournaments include: Samba, Rumba, cha-cha, jive, paso doble. There are many utility dances that are also constantly developing and evolving, as a result of which new styles of existing dances are created. This group includes, among others: salsa, bachata, mambo, rock and roll, Argentine tango, kizomba, twist, swing [7], [24].

The aim of this study was to assess the level of static and dynamic balances on dancers of regularly selected Latin American dances by comparison with non-dancers and also to check the correlation between selected balance parameters.

2. Materials and methods

Study design

The study was conducted among dancers attending dancing schools in Kraków and students of the Jagiellonian University Collegium Medicum in the period from January to March 2019. Participants were also recruited at dancing schools as well as through social media and personally by the authors. Each study participant was informed about its purpose, course and the possibility of resigning from participation at each stage of the study, as well as gave voluntary consent to participate in the experiment. In order to gather information on basic anthropometric characteristics of participants and inclusion/exclusion criteria, the author's original questionnaire was used, consisting of closed and open type questions regarding the type of dance, length and frequency of the training period, additional physical activities, problems with balance and previous injuries to the musculoskeletal system. The questionnaire was administered to the participants personally by the authors to avoid potential misunderstandings.

Inclusion criteria for both groups were:

– age over 18 years and under 40 years,
– no injuries to the musculoskeletal system in the last 5 years,
– no illness and not taking any medications that may affect balance,
– no additional regular physical activity.

Additional inclusion criteria for dancing people:

– regular salsa and/or bachata dancing for a minimum of a year,
– attending classes at least twice a week for min. 1 hour.

Ninety-three people completed the survey. After considering the inclusion criteria, 71 people were qualified for the study. The remaining 22 people were excluded due to the failure to meet the inclusion criteria. The causes were injuries (ankle sprains, anterior cruciate ligament rupture in the knee, bone fractures) and also practicing of additional physical activities that could affect the participant's balance (including yoga, fencing, other types of dance, going to the gym more often than two times a week after an hour).

Participants

The study group (dancers) consisted of 34 people – 17 women and 17 men. Their average age was 27.82 ± 3.88 years, BMI = 22.34 ± 2.53. The control group composed of non-dancing people consisted of 37 people – 14 men and 23 women. The average age was 27.24 ± 3.52 years, BMI was 22.5 ± 2.11 (Table 1). Among the respondents, 9 people practiced salsa (26%), 15 people bachata (44%) and 10 people (29%) practiced both of these dances.

Static balance test using a SIGMA balance platform

The SIGMA balance platform (AC International East) is a tool for assessing and training balance and, proprioception on unstable surfaces. It has four pads of different sizes (S–XL), that allow to adjust the dif-

Table 1. Descriptive statistics of anthropometric parameters in both investigated groups

Parameter	Non-dancers (n = 34)				p	Dancers (n = 37)			
	$\bar{x}$	SD	Min	Max		$\bar{x}$	SD	Min	Max
Age [years]	27.24	3.52	21	35	0.511	27.82	3.88	22	35
Weight [kg]	67.24	10.84	48	93	0.743	66.38	11.18	47	86
Height [cm]	171.95	9.82	158	195	0.849	171.50	9.75	152	193
BMI	22.5	2.11	17.92	27.1	0.778	22.34	2.52	17.84	27.44

Legend: $\bar{x}$ – arithmetic mean of a sample, SD – standard deviation, Min. – minimum value of a sample, Max. – maximum value of a sample, BMI – body mass index.

ficulty of tests and exercises. The described study used an XL pad with a diameter of 12 cm. The subject was supposed to take a free-standing position on the platform, without shoes and with eyes open. The feet were to be parallel to each other within the field designated by the platform (Fig. 1). The participant's task was to maintain the point displayed on the computer monitor for 60 seconds, as close as possible to the intersection of the *X* and *Y* axes. This point was the real-time mapping of the center of foot pressure (COP) on the ground. Each participant has only one attempt to the test. The platform registered changes in point location and recorded following parameters:

- the length of the path covered by COP – Path length [cm],
- the area covered by the COP chart – Pp [cm^2],
- the average deviations on each axis – dev. *X*, dev. *Y* [cm],
- velocities on each axis – *VX*, *VY* [cm/s].

Fig. 1. A person standing on SIGMA balance platform

Dynamic balance test using a Y-Balance Test (YBT) platform

It is a simple tool used to assess dynamic balance and stability. It consists of a base and measuring rods with centimeter scale and pads for rods. The examined person was supposed to stand on the base with his right leg, while the left one performed 3 correctly made maximum swings in each of the following directions: anterior (A) (Fig. 2), posteromedial (PM) (Fig. 3) and posterolateral (PL) (Fig. 4), touching the red area on the pad with finger and moving it as far

Fig. 2. Anterior (A) swing

Fig. 3. Posteromedial (PM) swing

Fig. 4. Posterolateral (PL) swing

as possible on each rod. Then, the same procedure was performed standing on the left leg. In order for the individual's swing to be considered correct, the subject could not lose balance while performing it, touch the floor with their foot, lean on the top side of the pad or kick it. If any of these conditions occurred, the test had to be repeated. The length of the right lower limb, measured from the anterior superior iliac spine to the medial ankle, was also noted. The SS index (normalized score of single leg) was calculated successively by normalizing the average of the results of swing for each direction for each leg, by dividing them by the relative length of the right lower limb, measured from the anterior superior iliac spine to the medial ankle and multiplying the result by 100, CS (composite reach score) taking into account the sum of the results from each of the directions and the relative length of the right lower limb according to the following formula: CS = (anterior + posteromedial + posterolateral) / (3 × right lower limb length) × 100. The difference between the individual results of swings (DA, DPL, DPM) obtained for both legs, expressed as the absolute value of the number obtained by subtracting the result for the dominant leg from the result for the opposite leg was also calculated [20].

Statistical analysis

Statistica 13.3 (StatSoft, Inc.) was used for statistical analysis. Elements of descriptive statistics were used to compare somatic characteristics of both groups. The compliance of the distribution of variables with normal distribution was assessed with the Shapiro–Wilk test. Depending on the result of the assessment of distribution normality the Mann–Whitney *U*-test or Student's *t*-test for independent variables was used to compare the means of assessed variables. In addition, Spearman's rank correlation coefficient of selected parameters was performed. Standard significance level $p < 0.05$ was used in all calculations.

Results

Sigma platform results

During analysis of the results of tests carried out on the Sigma platform, the path length, surface area (Pp), deviations (dev.) from the *X* and *Y* axes and COP speed (*V*) were assessed. The last two values were expressed as the absolute value of the number. A smaller range of minimum and maximum values of the surface area and path length as well as slightly higher values of these parameters and also the speed of movement of the COP in the planes of individual axes in was noted dancing people, however these differences were not statistically significant ($p > 0.05$) (Table 2).

Table 2. Descriptive statistics of the results of selected parameters on the SIGMA balance platform in individual groups

Parameter	Non-dancers					Dancers					*p* (UMW)
	Me	Q1	Q3	Min	Max	Me	Q1	Q3	Min	Max	
Path length [cm]	21.14	17.08	28.13	8.89	48.35	23.23	18.47	29.58	13.49	38.54	0.400
Pp [cm^2]	0.31	0.23	0.46	0.07	0.82	0.36	0.24	0.49	0.14	0.66	0.899
dev. *X* [cm]	0.03	0.02	0.04	0.01	0.09	0.03	0.02	0.05	0.00	0.11	0.609
dev. *Y* [cm]	0.03	0.02	0.06	0.00	0.12	0.03	0.01	0.06	0.00	0.16	0.895
V X [cm/s]	0.23	0.17	0.3	0.09	0.54	0.27	0.2	0.33	0.12	0.68	0.091
V Y [cm/s]	0.23	0.2	0.31	0.1	0.63	0.29	0.21	0.32	0.17	0.8	0.162

Legend: Pp – surface area, dev. – deviation, *X* – horizontal axis, *Y* – vertical axis, *V* – COP velocity, Me – median of a sample, Min. – minimum value of sample, Max. – maximum value of a sample, Me – the middle average of a sample, Q1, Q3 – extreme quartiles, UMW – Mann–Whitney *U*-test, *p* – level of significance

YBT platform results

The results of analysis for parameters obtained on YBT platform were not statistically significant ($p > 0.05$), however, slightly higher values of PM and PL inclinations were observed in the group of the dancing people. Also, the component of all three directions had a higher value than that of the dancing people. Turning in direction A no differences were noticed (Table 3).

The analysis of correlation between deviations from the X and Y axes and the surface area among the examined persons showed statistically significant but average strength correlation between the deviation from the Y axis and the surface area in the group of non-dancing people ($p = 0.018$). Other correlations were not statistically significant (Table 5).

After analyzing correlation between path length and surface area, a statistically significant correlation was found between those parameters in both studied

Table 3. Descriptive statistics for measuring parameters consistent with the normal distribution on the YBT platform

Parameter	Non-dancers				Dancers				p (t)
	$\bar{x}$	SD	Min	Max	$\bar{x}$	SD	Min	Max	
R SS A	0.71	0.06	0.61	0.82	0.71	0.08	0.59	0.94	0.858
R SS PM	1.1	0.08	0.92	1.24	1.14	0.12	0.83	1.33	0.254
R CS	0.95	0.07	0.79	1.05	0.97	0.09	0.73	1.13	0.419
L SS A	0.70	0.06	0.56	0.83	0.70	0.07	0.56	0.85	0.265
L SS PL	1.06	0.09	0.87	1.23	1.08	0.11	0.8	1.26	0.699
D PL	0.06	0.03	0.00	0.16	0.04	0.03	0.00	0.12	0.130

Legend: A – anterior, PM – posteromedial, PL – posterolateral, SS – normalized score of single leg, CS – normalized composite reach score, D – difference , $\bar{x}$ – arithmetic mean of a sample, L – left, R – right, SD – standard deviation, Min. – minimum value of a sample, Max. – maximum value of a sample, t – Student's t-test, p – level of significance.

Table 4. Descriptive statistics for parameters incompatible with the normal distribution on the YBT platform

Parameter	Non-dancers					Dancers					p (UMW)
	Me	Q1	Q3	Min	Max	Me	Q1	Q3	Min	Max	
R SS PL	1.05	1.0	1.13	0.76	1.21	1.07	1.0	1.16	0.78	1.26	0.322
L SS PM	1.13	1.04	1.18	0.93	1.25	1.15	1.11	1.25	0.81	1.3	0.139
L CS	0.98	0.9	1.02	0.81	1.07	0.99	0.94	1.05	0.75	1.12	0.234
D A	0.03	0.014	0.056	0.003	0.19	0.02	0.004	0.035	0.00	0.16	0.17
D PM	0.04	0.014	0.057	0.00	0.16	0.037	0.016	0.059	0.003	0.12	0.98

Legend: A – anterior, PM – posteromedial, PL – posterolateral, SS – normalized score of single leg , CS – normalized composite reach score, D – difference, L – left, R – right, Me – median of a sample, Min. – minimum value of sample, Max. – maximum value of a sample, Me – the middle average of a sample, Q1, Q3 – extreme quartiles, UMW – Mann–Whitney U-test, p – level of significance.

Differences in individual deflections were not statistically significant ($p > 0.05$). The difference between the right and left lower limbs, according to the Mann–Whitney U-test, was not statistically significant in both the dancing group and the control group in the directions: DA ($p = 0.17$) and DPM ($p = 0.98$). Differences between individual swings in the Mann–Whitney U-test were not statistically significant ($p > 0.05$). The difference between the right and left lower limbs, according to the Mann–Whitney U-test, was not statistically significant in both groups in the directions: DA ($p = 0.17$) and DPM ($p = 0.98$) (Table 4).

Table 5. Spearman's rank correlation coefficients between deviations from the axis and the surface area in the examined groups

Group	Pairs of variables	r_s	p
Non-dancers	dev. X and Pp	0.2	0.237
	dev. Y and Pp	0.39	**0.017**
Dancers	dev. X and Pp	0.06	0.734
	dev. Y and Pp	0.02	0.914

Legend: Pp – surface area, dev. – deviation, X – horizontal axis, Y – vertical axis, r_s – Spearman's rank correlation coefficient value, p – level of significance.

groups, however, the dancers' correlation value was clearly lower. The analysis of the correlation between the velocities of the projection of the center of gravity on the axes and the surface area and path length showed a statistically significant, strong relationship in both groups, which was also smaller in the group of dancers (Table 6).

Table 6. Spearman's rank correlation coefficient between velocity, surface area and path length

Group	Pair of variables	r_s	p
Non-dancers	*V X* and path length	0.97	**0.000**
	V Y and path length	0.97	**0.000**
	V X and Pp	0.75	**0.000**
	V Y and Pp	0.79	**0.000**
	path length and Pp	0.79	**0.000**
Dancers	*V X* and path length	0.79	**0.000**
	V Y and path length	0.80	**0.000**
	V X and Pp	0.6051	**0.000**
	V Y and Pp	0.4951	**0.003**
	path length and Pp	0.5015	**0.003**

Legend: Pp – surface area, X – horizontal axis, Y – vertical axis, r_s – Spearman's rank correlation coefficient value, p – level of significance.

4. Discussion

In the examined group of dancers, surface area, path length and speed values tested on the SIGMA balance platform were found slightly higher, but in relation to the results obtained in the control group these results were not statistically significant. Also, analyzing the dynamic balance of the dancers, no significant differences were found in the YBT study compared to the control group. These results are consistent with those obtained by Serra et al. [23], who stated no significant differences in balance between elderly women dancing samba and non-dancing women. It is important to note that those authors who evaluated balance in the eye-open and eye-closed conditions. Significant differences were found between two groups in eye-closed conditions, which supports the importance of vision in maintaining balance. Also, Chatzopoulos et al. [5], who compared proprioception, rhythm and balance in two groups of preschool children, found no significant differences in static balance between a group of children who took part in the creative dancing program and children that participated in regular free play setting.

Analysis of the results of the differences in measurements between the right and left legs, shows that it is noticeably smaller in dancers. This may suggest greater body symmetry, less difference between the right and left sides, which may result in better static balance. This could be confirmed by the results of studies presented in the work of Michalska et al. carried out among ballet dancers and Ambegaonkar et al. who studied the differences between dancing and non-dancing, but physically active women. Increased postural sway allows for quick and precise change of body position, which is crucial in dancing. Due to the fact that dancers during training must maintain balance while rapidly changing specific figures, which are often very unstable and, they do not hold on to them long. Due to that they do not present better static balance in the study in free standing position than non-dancing people, but show higher level of dynamic balance [1], [6], [17], [21]. In our study, the differences between the other parameters were also not statistically significant, but nevertheless, higher swing results for the right and left legs in the group of dancers in PL and PM can be noticed, while there are no differences in A direction. Based on the results of studies of other authors, it can be assumed that comparable results of forward swing in both groups are caused by the fact that this swing is similar to the movement performed during walking, so each study participant uses this direction in everyday life [8], [22]. On the other hand, posterolateral and posteromedial directions are used in dancing, and they are lacking in everyday activities. Therefore, it can be suggested that dancers show higher ranges of movement in these directions.

Despite the lack of statistical significance of the correlation between lateral deviations and the surface area between the groups, it can be seen that the values of this correlation in the control group are higher than in the group of dancing people ($r_s = 0.2$ vs. $r_s = 0.06$). This difference is much more evident in the results of deviations in the sagittal plane ($r_s = 0.39$ vs $r_s = 0.02$). This could indicate a better static balance of dancers as in this group surface area is less dependent on lateral deviations. This claim seems to be supported by the results that were obtained by Stawicki et al. [25], who investigated static balance of young females regularly practicing modern and/or classical dance in comparison to control group. In that study, the balance was assessed using balance platform in various positions with eyes open and closed. The authors stated better results characterizing the displacement of COP in dancers compared to non-dancers. It is also noteworthy that investigated group of dancers had more demanding inclusion criteria than dancers in our study as they practiced dance for minimum 7 years at least three times a week.

In our study, we also stated a statistically significant correlation between the surface area and the path length, but it was lower in the dancing group than in the control group. Similar relationships can be seen for the correlation between velocities and surface area, as well as between velocities and path length. This may indicate that the dancers use a different strategy to maintain balance, consisting of reducing the amplitude of deflections at the expense of a higher frequency of oscillation of the center of gravity projection. This can be a sign of balancing the center of gravity, in order to quickly change position, which is a dynamic adaptation to changing figures in dance. This assumption is similar to that made by de Mello et al. [19]. In the study with research methods similar to ours (stabilometric platform), they compared the balance of professional ballet dancers and non-dancers. They also stated bigger values of COP displacement in dancers than those who are non-dancers. As they supposed, this could be the result of inadequate postural stability or specific behavior to maintaining postural stability in more challenging tasks, however, it should be mentioned that positions used in that study (single-leg stance) were more demanding that in our study.

One of the limitations of our study was that participants were relatively young. Probably the effect of dancing could be more visible in older persons which can be supported by the research conducted by Verghese [29] among senior ballroom dancers. That research confirms better balance and faster gait for people who dance regularly throughout their lives (for between 3 and 75 years). Also, Granaher et al. [10] stated that 8-week training based on salsa has a positive effect on the balance of older people and reduces the risk of falls. Federici et al. [9] assessed the effect of dance-based training program on balance in elderly and middle-aged people. They stated significant improvement in balance tests (Tinetti, Romberg Sit up and go) compared to control group. However, it should be noticed that these authors, used different assessment tools that were better adjusted to the elderly persons.

Another limitation is the assessment of only two types of dancing. It is possible that other dancing types may present more visible impact on healthy people than those assessed by us. Study of Krityakiarana and Jongkamonwiwat [15] that compared Thai classical dancers to non-dancers showed significantly better balance performance in dancers. Also, Barnhuke et al. [3] investigated the impact of Indian classical dances on balance in young female dancers compared to non-dancers. They stated significantly better balance of dancers assessed by Star Excursion Balance Test (SEBT) which is quite similar to the YBT used in our study. In turn, Kattenstroth et al. [13] found substantially better level of balance in long-year expert senior ballroom dancers compared to non-dancing controls.

These facts confirm that further studies using objective research tools and including subgroups of different age and different types of dances should be conducted to specify the influence of particular dance types on static and dynamic balance.

5. Conclusions

The level of dynamic balance of dancing people is similar when compared to non-dancers. Practicing Latin American dances may improve static balance, however, this effect requires detailed confirmation in further studies.

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