CHANGES IN MOTOR AND MORPHOLOGICAL MEASURES OF YOUNG WOMEN INDUCED BY THE HI-LO AND STEP AEROBIC DANCE PROGRAMMES

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Abstract:

In previous studies a number of authors have already demonstrated the positive changes in certain dimensions of the anthropological status of female aerobic dancers induced by various treatments of modern aerobic dance programmes. Changes in motor space have been, however, rarely investigated. The authors have attempted in the present paper to define the potential differential training effects of the step (N = 24) and hi-lo (N = 23) aerobic dance programmes and to analyse the changes in the morphological (variables assessing voluminosity of the body and skinfold thickness) and motor (coordination, flexibility, movement frequency) measures of college-aged female participants. The entire programme consisted of a total of 25 separate aerobics training sessions (three times a week; each session of 60 min). Each session encompassed cardio-section routines, which consisted of the experimental aerobic dance programmes (35 min), strength-developing exercises (15 min) and stretching exercises (10 min). The results, obtained by means of ANOVA and discriminant analysis, suggest both programmes resulted in reduced skinfold measures and in improved measures of flexibility, coordination in rhythm and, to a lesser extent, measures of movement frequency. No differential influence of the two programmes of aerobic dance was confirmed.

Key words: *training effects, morphology, motor abilities, analysis of variance, discriminant analysis, leisure-time sport*

DIE VON DEN HI-LO- UND AEROBIC-TANZ-PROGRAMMEN BEWIRKTEN VERÄNDERUNGEN IN MOTORISCHEN FÄHIGKEITEN UND MORPHOLOGISCHEN EIGENSCHAFTEN BEI JUNGEN FRAUEN

Zusammenfassung:

In vielen bisherigen Forschungen wiesen die Autoren auf positive im modernen Aerobic-Training entstandenen Veränderungen einzelner Abmessungen im anthropologischen Status der Aerobic-Tänzerinnen hin, wobei die Veränderungen in motorischen Eigenschaften dagegen selten untersucht wurden. In dieser Arbeit ist man bemüht, die potentiell unterschiedlichen Auswirkungen von Step- (N=4) und HI-LO-Aerobicprogrammen (N=23) festzustellen, aber auch die Veränderungen in morphologischen Eigenschaften (Variablen zur Feststellung von Körperumfängen und von Dicke der Hautfalten) und motorischen Fähigkeiten (Koordination, Gelenkigkeit, Bewegungsfrequenz) bei den Programmteilnehmerinnen, die 18 – 21 Jahren alt waren, zu untersuchen. Das Gesamtprogramm bestand aus 25 Trainingseinheiten (3mal wöchentlich je 60 Minuten die Dauer). Jede Trainingseinheit schloss das Cardio-Training ein, das aus experimentalen Aerobic-Tanz-Programmen (35 Minuten), Kraftübungen (15 Minuten) und Dehnungsübungen (10 Minuten) bestand. Die mittels der Varianz- und Diskriminanzanalyse erhaltenen Resultate weisen darauf hin, dass beide Programme sowohl zur Abnahme von Maßzahlen der Hautfalten als auch zur Verbesserung in der Gelenkigkeit und Rhythmus-Koordination führen aber die Bewegungsfrequenzen nur gering beeinflussen. Keine differenzierbaren Einflüsse zwischen den beiden Aerobic-Tanz-Programmen wurden festgestellt.

Schlüsselwörter: *Trainingseffekte, Morphologie, motorische Fähigkeiten, Varianzanalyse, Diskriminanzanalyse, Freizeitsport*

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Introduction

Modern aerobic dance continues to enjoy widespread popularity. Aerobics programmes are among the most frequently and mass participated-in modalities of organized recreational physical exercise activities. The immense number and variety of aerobic dance styles and variations, or work modalities, have undoubtedly contributed to the boom in popularity of this sports-recreational activity (Zagorc, Zaletel & Ižanc, 1996; Metikoš, Zagorc, Prot, Furjan-Mandić & Zaletel, 1997). Yet, all forms of aerobics, no matter how different the programmes may be (step, HI-LO, slide, funky, etc.), are primarily characterised by a fairly easy and precise prescription and control of workload or exercise intensity. The intensity is basically of an aerobic or moderate anaerobic nature (De Angelis, Vinciguerra, Gasbarri & Paciti, 1998; Sekulić, 1997; Sekulić, Rausavljević & Žvan, 2001) with a series of confirmed transformational effects (especially in cardio respiratory fitness). Previous aerobic dance studies investigated mostly (and frequently demonstrated) the positive effects of aerobics on changes in body composition (Shimamoto, Adachi, Takahashi & Tanaka, 1998; Sekulić, Furjan-Mandić & Kondrič, 2001), and the positive changes in the measures of aerobic fitness as well (Kravitz, Cisar, Christensen & Setterlund, 1993). Motor changes in aerobic dancers have been rarely investigated. The question, however, arises: are all modern aerobic dance programmes equally efficacious in accomplishing particular transformational effects?

The answers can be probably obtained from research studies of the transformational effects of different modalities of aerobic dance training with groups of male or female participants who achieved comparable measurement results prior to the experimental programme implementation. Certain authors have already addressed the issue and compared various aerobic dance programmes. Berry MJ, Cline, Berry CB and Davis (1992) analysed the physiological responses to current aerobics programmes and treadmill running. They determined there were no significant differences in the parameters of physiological loads between these programmes. Kravitz, Cisar, Christensen and Setterlund (1993) compared the physiological effects of the two step training modalities (with and without handweights) and found much the same changes in measures of strength/power, body composition and certain cardiorespiratory parameters. In several research studies the effects of aerobic dance programmes were compared to the effects of other training forms, such as walking and jogging /running (Garber, McKinney & Carleton, 1992).

Some general conclusions can be drawn from the mentioned investigations:

- Under the conditions of equal physiological demands (workload), various forms of aerobic dance programmes are evenly efficacious in the transformations of morphological status of subjects:
- Under the conditions of equal physiological demands (workload), various forms of dance aerobic programmes produce identical changes in the aerobic capacities of subjects.

However, as mentioned before, investigations determining the influence of aerobics programmes on motor abilities are rare. One of the few was conducted by Bobo and Yarborough in 1999. The authors analysed the differences in agility and flexibility between experienced and less experienced aerobic dance instructors. The experienced instructors consisted of a group of veteran aerobic dancers with a long training and teaching experience. Their motor status was compared to the status of the less experienced aerobics instructors whose motor abilities should have been, the authors supposed, on the level characteristic for the veteran aerobic dancers in the beginning of their chronic participation in aerobics programmes. No significant differences between the two groups of experienced and less experienced aerobics instructors were obtained. Therefore, the authors concluded that chronic participation in aerobic dance does not facilitate the improvement of the range of motion of the antigravity muscles, nor does the movement involved in aerobic dance improve the instructors' ability to coordinate motor movement in a complex movement pattern, that is, in the measures of flexibility and agility. These results can hardly be generalised to the wider population even if we do not analyse the study too critically. Namely, the research is a cross-sectional study with a small number of analysed variables. The investigation of Kravitz, Cisar, Christensen and Setterlund (1993) is, from the aspect of our research, more interesting. The authors investigated, among other issues, the influence of eight weeks of step aerobic dance training on changes in numerous physiological measures, including the measures of muscle strength. The results showed significant improvement in this segment of the motor abilities induced by the chronic step aerobic dance participation.

Information concerning the influence of aerobic dance programmes on changes in various dimensions of motor status is still insufficient, especially when the differential influence of diverse aerobic dance programmes is regarded.

Therefore, the present research had two goals:

- To determine the individual effects of two aerobic dance programmes: step and HI-LO on changes in the morphological and motor status of initially equal groups of young women (participants in both groups scored evenly in all the measured variables prior to the experiment);
- To determine the differential effects of the applied programmes of modern aerobic dance in the analysed motor and morphological variables.

Methods

Participants. The sample of participants consisted of two groups of female students. The first group (N = 24) participated in the HI-LO aerobic dance programme, whereas the second group (N = 23) was engaged in the step-aerobics programme. All the participants were at the time of experiment 18-21 years old, with an average body weight of 60.25 ± 6.3 kg.

Sample of variables. The complete sample consisted of eight morphological and eleven motor variables. The motor variables (all measured according to Metikoš, Hofman, Prot, Pintar & Oreb, 1989) consisted of three variables assessing coordination in rhythm (*hand drumming a specified rhythm pattern* – MKRBUB, *drumming a specified rhythm pattern on surfaces* – MKRPLH and *hand and leg drumming a specified rhythm pattern* - MKRBNR). It is expected that aerobic dance programmes, due to their fusion with rhythmic and dance movement structures, may have a positive influence on the changes in the space of coordination in rhythm. Namely, the authors presume, according to their years-long experience in aerobics, a portion of the variance of the measured motor space pertains to the specific *motor manifestation of rhythm*, which can probably be improved by the application of adequate kinesiological stimuli.

Apart from the mentioned motor variables, three variables were used to assess general coordination (*obstacle course backwards* – MREPOL, *obstacle course with climbing up and down* – MBKPIS, *obstacle course with passing through and jumping over* – MBKPOP).

Two variables measured the frequency of movement (*hand tapping* – MFTAN and *foot tapping against a wall* – MFTAZ). Flexibility was assessed by means of three variables: flexibility of arms and shoulders was assessed with *back shoulder circumduction* – MFLISK, and flexibility of lower extremities was assessed by two variables: *straddle sit-and-reach* – MFLPRR and *forward bend on a bench* – MFLPRK). It was expected that the stretching part of the programmes (of both the step and HI-LO-aerobics), performed at the end of each session, might produce positive effects on flexibility in testees.

The set of variables assessing the anthropometric and morphological characteristics was so composed to include variables describing the morphological dimensions of body voluminosity and subcutaneous fatty tissue (non-adipose voluminosity and adiposity, according to Hošek-Momirović, 1981). The anthropometric variables (measured by the protocols from ***Morphological anthropometry in sport***, by Mišigoj-Duraković, 1995) consisted of: four measures of circumferences (*upper arm circumference* - AONAD, *waist circumference* - AOTRB, *thigh circumference* - AONAT and *lower leg circumference* - AOPOT) and four skinfold measures (*upper arm skinfold* - AKNNAD, *abdominal skinfold* - AKNTRB, *thigh skinfold* - AKNNAT and *calf skinfold* - AKNPOT). The choice of variables should cover the expected changes in the particular parts of the body.

Experimental programme lasted nine weeks, three sessions a week. Prior to and after the programmes, the initial and final testing were conducted. A total of 25 individual training sessions was realised in each programme. The structure of a single session was identical for the step and HI-LO aerobics programme. Each session started with a warm-up section (5 min), then came the cardio-section (30 min of exercising in an aerobic regimen of work – described in the following text) followed by 15 minutes of strength exercises (5 min for the abdominal region, 5 min for the low back, and 5 min for arms, shoulder and chest), and, at the end, by 10 minutes of supported stretching (Anderson, 1997).

The differences between the two programmes were based on traditional comparative characteristics of the step and HI-LO aerobic dance programmes. So, the cadence in the step routines ranged between 120 and 130 beats/min, whereas in the HI-LO routines it ranged between 130 and 155 beats/min. In the step classes no movements containing hops, jumps, or leaps were used, as opposed to the HI-LO classes in which hops and jumps were regular components of the cardio-section. No implements were utilized in the HI-LO programme, whereas step platforms 15 cm high were used in the step programme. Each session of the step aerobics programme was composed of two equal time sections in which moves from the two main groups were performed: movements of a low energy cost (aerobic) and movements of a higher level of energy cost (aerobic-anaerobic) (Sekulić, 1997). In the 30-minute part of the step training session a total of 15 minutes was devoted to routines of a low energy cost (basic-step, knee-up, kick step, V-step, turn-step, curl-step), whereas the other 15 minutes were made up of routines of a higher energy cost (repeater-step, over-step, hoop-step, pony-step), as well as of their variations and combinations. Special attention was focused on equal loading of both legs.

The HI-LO programme was composed of three main groups of routines (each group was performed for 10 minutes): *lo(w)-impact* moves (push touch, side-to-side, leg curl, step-touch, V-step, A-step, walk), *moderate impact* moves (grapevine, repeater, repeater kick, repeater curl, mambo step, twist) and *hi(gh)-impact* moves (jumping-jack, hoop, cha-cha-cha step, pony step, step aside, jogging), as well as their variations and combinations (Željković & Metikoš, 1997).

Apart from the already mentioned differences, the step and HI-LO programmes differed manifestly in the following characteristic details as well:

- in the HI-LO aerobics the work intensity is determined by the quicker cadence of the routine performance, executed on the floor (a horizontal plane), so no extra workload was implemented;
- in the step aerobics programme the cadence of performance is a little bit slower than in the HI-LO programme, but intensity is higher due to the constant stepping on and off the step platform;
- movements used in the HI-LO aerobic dance are relatively natural and known to the participant (walking, running, hops, jumps, etc.);
- participants were not quite familiar with the movements used in step aerobics (alternate stepping on the bench and stepping off it in all directions and planes).

The workload or training intensity was controlled in each training session by means of heart rate monitors POLAR, Finland (model ACCUREX plus). The average heart rate was 162.43 beat/min and 162.90 beat/min for the HI-LO and step participants, respectively (no significant difference). These parameters were analysed to a detail in the paper by Sekulić, Rausavljević and Žvan (2001).

Data processing methods. Factor analysis with varimax rotations, under the Guttman-Kaiser criterion, was applied to the variables assessing motor abilities and to the variables assessing morphological characteristics separately. In that way the factor structure of the applied set of variables was determined. Namely, as far as the authors know, the metric characteristics of the utilized sets of variables have been so far defined only for a sample of men (Metikoš et al., 1989).

Arithmetic means (M - Mean) and standard deviations (SD) were calculated with the results of the initial and final measurements.

Discriminant analysis was employed to determine the significance of differences between the two groups in the initial and final measurement for the motor and morphological (anthropometric) variables separately.

The changes (transformations) and differences were processed by the analysis of variance in order to obtain:

- Significance of changes in the HI-LO group;
- Significance of changes in the step-aerobics group;
- Significance of differences between the HI-LO and the step-aerobics group in the initial testing;
- Significance of differences between the HI-LO and the step-aerobics group in the final testing.

All the differences at a $p \leq 0.05$ level of significance were retained.

The data were processed with the statistical software package Statistica for Windows, ver. 5.0, at the Faculty of Mathematics, Sciences and Education, University of Split, Croatia.

The authors of the present study are quite aware of the limits imposed on the interpretation of the results by the fact that the participants were a relatively selected sample (of a small age span, primarily). However, the demanding nature of the experiment (nine weeks of training, or measurement of a considerable number of variables, just to mention a few) required the kind of selection of subjects who were determined to participate in the experiment from the beginning till the end. Other researchers also encountered the same problem when designing and conducting their experiments investigating the influence of aerobic dance programmes (for example, McCord, Nichols & Patterson, 1989, Kravitz et al., 1993).

Results

Table 1. Varimax factorial structure of motor and morphological space (correlations of variables with a factor – F, variances of factors – Expl. Var)

MOTOR ABILITIES				MORPHOLOGICAL CHARACTERISTICS		
	F1	F2	F3		F1	F2
MBKPOP	0.83	0.00	-0.24	AKNNAD	0.24	0.86
MREPOL	0.86	0.09	-0.21	AKNTRB	0.00	0.90
MBKPIS	0.14	-0.06	-0.04	AKNNAT	0.32	0.60
MKRBUB	-0.17	0.14	0.87	AKNPOT	0.02	0.57
MKRPLH	-0.57	0.37	0.61	AONAD	0.79	0.07
MKRBNR	-0.25	-0.19	0.78	AOTRB	0.89	0.14
MFTAZ	-0.05	0.21	0.56	AONAT	0.86	0.30
MFTAN	-0.68	0.12	0.20	AOPOT	0.76	-0.12
MFLISK	0.40	0.45	0.12			
MFLPRK	-0.10	-0.89	0.00			
MFLPRR	0.15	-0.91	-0.08			
Expl.Var	2.52	2.06	2.22	Expl.Var	2.90	2.36

MKRBUB - hand drumming a specified rhythm pattern, MKRPLH - drumming a specified rhythm pattern on surfaces, MKRBNR – hand and leg drumming a specified rhythm pattern, MREPOL - obstacle course backwards, MBKPIS - obstacle course with climbing up and down, MBKPOP - obstacle course with passing through and jumping over, MFTAN - hand tapping, MFTAZ - foot tapping against a wall, MFLISK - back shoulder circumduction, MFLPRR - straddle sit-and-reach, MFLPRK - forward bend on a bench, AONAD - upper arm circumference, AOTRB - waist circumference, AONAT - thigh circumference, AOPOT - lower leg circumference, AKNNAD - upper arm skinfold, AKNTRB - abdominal skinfold, AKNNAT - thigh skinfold, AKNPOT - calf skinfold

According to the factor structure (Table 1), three significant factors were isolated in the space of motor abilities. The first factor may be named as the FACTOR OF COORDINATION (high projections of the variables *obstacle course with passing through and jumping over* - MBKPOP and *obstacle course* backwards - MREPOL), the second as the FACTOR OF FLEXIBILITY (high projections of the variables *forward bend on a bench* - MFLPRK and *straddle sit-and-reach* - MFLPRR, and moderate to high projection of the variable *back shoulder circumduction* - MFLISK). With the third factor (COORDINATION IN RHYTHM) high projections of the variables assessing coordination in rhythm (*hand drumming a specified rhythm pattern* - MKRBUB, *drumming a specified rhythm pattern on surfaces* - MKRPLH and *hand and leg drumming a specified rhythm pattern* - MKRBNR) were isolated together with the obvious projection of the variable assessing frequency of movement (*foot tapping against a wall* - MFTAZ).

In the space of morphology two significant factors were isolated: the FACTOR OF VOLUMINOSITY – with high projections of all the variables assessing circumferences of the body regions, and the FACTOR OF SUBCUTANEOUS FAT TISSUE (high correlations with all the measures of skinfold thickness). The results of the factor analysis will not be discussed further in the text. Still, this methodological procedure should be conducted and addressed here because it allowed the determination of the factor validity of the employed measures, which were rarely, if ever, metrically verified with the female samples. Generally, the variables having high correlations with individual factors may be considered as the best representatives of particular latent dimensions.

The four discriminant analyses revealed no significant differences between the groups in the scores of the initial and final measurements (neither in the motor nor in the morphological space of variables). Consequently, no global differences between the groups were established either in the initial or in the final measurement.

Table 2. Results of discriminant analysis of the initial and final measurements (Wilks' lambda and level of significance – p)

	INITIAL	FINAL
MOTOR ABILITIES	Wilks' lambda = 0.45 p = 0.32	Wilks' lambda = 0.42 p = 0.36
MORPHOLOGICAL CHARACTERISTICS	Wilks' lambda = 0.64 p = 0.44	Wilks' lambda = 0.76 p = 0.79

Table 3. Descriptive statistics of the initial and final measurements (arithmetic mean – M, and standard deviation – SD), ANOVA (p-level)

	Initial				Final				ANOVA			
	HI-LO		STEP		HI-LO		STEP		In:Fin		HILO : STEP	
	M	SD	M	SD	M	SD	M	SD	HI-LO	STEP	In	Fin
MBKPOP (s)	16.4	2.1	17.8	4.6	15.1	2.4	14.5	2.7	0.06	0.02	0.36	0.47
MREPOL (s)	11.2	2.0	10.8	2.0	9.4	1.3	9.0	0.9	0.02	0.01	0.63	0.24
MBKPIS (s)	21.0	3.8	21.1	2.5	15.4	2.3	16.7	2.5	0.00	0.00	0.96	0.23
MKRBUB (f)	14.6	1.8	13.3	1.8	18.2	2.1	16.2	1.9	0.00	0.00	0.10	0.02
MKRPLH (f)	25.9	5.3	24.0	6.0	32.1	5.2	32.1	5.8	0.00	0.02	0.43	0.78
MKRBNR (f)	9.3	2.4	9.9	1.9	12.8	3.0	12.3	2.2	0.00	0.01	0.51	0.49
MFTAZ (f)	22.0	3.1	20.4	1.6	23.6	3.5	21.7	2.5	0.09	0.17	0.13	0.11
MFTAN (f)	40.0	2.4	40.0	3.5	43.8	3.1	43.2	4.6	0.00	0.00	1.00	0.60
MFLISK (cm)	69.4	9.7	66.4	12.0	71.8	10.6	68.7	16.5	0.18	0.59	0.51	0.42
MFLPRK (cm)	51.2	4.8	54.1	4.6	54.8	4.1	57.1	4.0	0.00	0.00	0.14	0.21
MFLPRR (cm)	74.2	9.7	77.6	12.1	77.7	10.3	80.5	8.0	0.02	0.06	0.46	0.62
AKNNAD (mm)	13.7	3.3	14.3	4.1	9.8	3.7	12.0	5.1	0.00	0.02	0.71	0.74
AKNTRB (mm)	11.6	3.9	12.0	4.6	10.5	4.0	10.6	3.9	0.01	0.00	0.82	0.37
AKNNAT (mm)	17.8	1.7	17.9	4.4	16.6	1.9	15.1	3.3	0.03	0.14	0.96	0.15
AKNPOT (mm)	17.6	5.3	15.0	3.1	16.2	5.2	13.3	2.3	0.00	0.01	0.15	0.13
AONAD (cm)	25.1	1.6	26.4	2.6	22.7	1.7	24.0	2.3	0.10	0.16	0.15	0.41
AOTRB (cm)	71.4	5.9	73.4	7.2	70.0	4.8	70.8	5.5	0.08	0.19	0.47	0.15
AONAT (cm)	55.4	2.6	57.6	5.5	56.7	5.5	56.0	3.9	0.40	0.16	0.23	0.63
AOPOT (cm)	35.1	2.7	36.8	2.6	35.7	1.6	35.8	2.0	0.47	0.19	0.14	0.75

MKRBUB - hand drumming a specified rhythm pattern, MKRPLH - drumming a specified rhythm pattern on surfaces, MKRBNR – hand and leg drumming a specified rhythm pattern, MREPOL - obstacle course backwards, MBKPIS - obstacle course with climbing up and down, MBKPOP - obstacle course with passing through and jumping over, MFTAN - hand tapping, MFTAZ - foot tapping against a wall, MFLISK - back shoulder circumduction, MFLPRR - straddle sit-and-reach, MFLPRK - forward bend on a bench, AONAD - upper arm circumference, AOTRB - waist circumference, AONAT - thigh circumference, AOPOT - lower leg circumference, AKNNAD - upper arm skinfold, AKNTRB - abdominal skinfold, AKNNAT - thigh skinfold, AKNPOT - calf skinfold

Analysis of the results displayed in Table 3 reveals the finding that both groups accomplished significantly better scores in the final measurement than in the initial one in most of motor variables, and that significant changes (transformations) occurred in the morphological (anthropometric) variables in both groups.

In the HI-LO aerobic dance group the significant differences between the initial and the final measurement can be observed in the motor variables *obstacle course backwards* - MREPOL (according to the defined latent structure it is a measure of coordination), *obstacle course with climbing up and down* - MBKPIS, then in all the three variables assessing coordination in rhythm (*hand drumming a specified rhythm pattern* - MKRBUB, *drumming a specified rhythm pattern on surfaces* - MKRPLH and *hand and leg drumming a specified rhythm pattern* – MKRBNR), in *hand tapping* - MFTAN, and in two variables assessing flexibility of the lower extremities (*forward bend on a bench* - MFLPRK and *straddle sit-and-reach* - MFLPRR). All the changes are positive, meaning that better results were accomplished in the final than in the initial measurement.

The step aerobics group made considerable progress in the measures of coordination (*obstacle course with passing through and jumping* over - MBKPOP and *obstacle course backwards* - MREPOL) and of coordination in rhythm (*hand drumming a specified rhythm pattern* - MKRBUB, *drumming a specified rhythm pattern on surfaces* - MKRPLH and *hand and leg drumming a specified rhythm pattern* - MKRBNR), in variables *obstacle course with climbing up and down* - MBKPIS and *hand tapping* - MFTAN, as well as in one variable assessing flexibility (*forward bend on a bench* - MFLPRK). In the rest of the motor variables the changes are not significant.

In the HI-LO participants the thickness of all skinfolds decreased significantly between the initial and the final measurement, whereas in the step aerobic dancers three out of four skinfold measures decreased significantly (the significant changes in the thigh skinfold thickness were missing). Changes in the body circumferences were not significant in either of the groups.

Discussion

The registered changes in the skinfold measures for subjects of both groups documented once again the positive influence of the step and HI-LO training on reduction of the subcutaneous fatty tissue. The significant reduction of fatty tissue in aerobic dancers was documented in the studies by McCord, Nichols and Patterson (1989) who obtained a significantly decreased percent of fat tissue (hydrostatic weighing) in the female students, participants in the 12-week lo-impact aerobic dance training (from 25 ± 6.8% to 21 ± 6.3%; $p < 0.01$), and by Kravitz and associates (1993) on the sample of 24 female students who participated in the 8-week step training. It is interesting in our study that there were no significant changes in the variables assessing the body parts' circumferences (voluminosity). Maybe the reduction in the measures of circumferences should have been expected with regard to the significant reduction in the skinfold measures. Therefore, it is viable to presume that a mild muscular hypertrophy occurred. So, we are simultaneously dealing here with increments in the lean body mass (enhanced muscularity), on the one hand, and with decrements in fat tissue (reduced body fatness), on the other. The phenomenon kept the measures of circumferences on the same, initial level. Very similar conclusions were presented in the mentioned investigation of Kravitz and associates (1993): the significant reduction in the endomorphic component of the body build (from 5.24 ± 0.18 to 4.93 ± 0.18; $p < 0.01$), with the simultaneous significant increase in the mesomorphic component of the body composition (from 3.22 ± 0.19 to 3.5 ± 0.19; $p< 0.01$) of the college-aged female students. The significant reduction of body fat was also indentified (from 15.13 ± 0.96 kg to 13.82 ± 0.96 kg; $p < 0.01$), together with numerical, but insignificant, increase in lean body mass (from 41.94 ± 1.24 kg to42.84 ± 0.99; $p = 0.07$).

The expected differential training programme effects were not obtained in the space of morphology. Namely, neither the discriminant analysis nor the analysis of variance between the two groups indicated any significant differences between the groups in the final measures. The probable cause for the phenomenon may be sought in much the same nature, i.e. magnitude of physiological loads (as expressed by the heart rate values) both groups were subjected to. According to the results presented here and in some previous studies (Blessing, Wilson, Puckett, & Ford, 1987; Kravitz et al., 1993), it seems as if the degree of the morphological changes depends exclusively on the magnitude of the physiological energy cost (the workload or training intensity is usually expressed in terms of heart rate, or blood lactate concentration, or VO_2 consumption). Consequently, work modalities and their manifest characteristics seem to have no crucial contribution to the morphological and differential influence of particular training programmes (Sekulić et al., 2001b). It regards primarily the manifest differences typical for the programmes of the step and the HI-LO aerobic dance. The musical accompaniment in step aerobics is a little bit slower (in our experiment the cadence ranged between 120 and 130 beats/min) than in the HI-LO dance (here the cadence ranged between 130 and 155 beats/min). Then, no routines consisting of hops, jumps, or leaps are utilized in step aerobics (as opposed to the HI-LO programme), but the load intensity is higher in the step aerobics than in the HI-LO programme due to the typical routines of stepping on and off a step platform. The absence of the differential influence is by no means surprising, because other researchers obtained similar results. For example, Garber, McKinney and Carleton (1992) determined that aerobic dance and walk-jog exercise training caused comparable transformational effects in functional and morphological parameters, if the same workload is applied.

The obtained changes in motor variables, induced by the influence of the two aerobic dance programmes, become even more interesting if we take into account the general shortage of information on changes in the motor status of aerobic dancers in referenced literature. The present authors, therefore, expected that the modern aerobic dance programme might have a positive influence on the changes in measures of coordination in rhythm. The significant differences between the initial and the final scores on the variables assessing this dimension (*hand drumming a specified rhythm pattern* - MKRBUB, *drumming a specified rhythm pattern on surfaces* - MKRPLH and *hand and leg drumming a specified rhythm pattern* – MKRBNR) confirmed the viability of the expectations. Both groups made considerable progress in all the listed variables. It seems as if the step and HI-LO programmes are appropriate stimuli for development of the mentioned abilities. In previous studies it was determined that coordination in rhythm has a positive influence on technique and quality of performance in various aerobic dance programmes (Sekulić, 2002). Consequently, the authors presume that a constant need to follow the rhythm and tempo of the musical accompaniment in each aerobic dance session makes a solid basis of positive stimuli for the development of coordination in rhythm. It is not possible to compare this finding to the results from other studies dealing with the effects of various aerobic dance programmes. Still, the finding is comparable to the results from the studies dealing with other kinesiological (sports) activities performed to music, like rhythmic gymnastics or dance, in which the positive changes in these dimensions have already been determined (Miletić, 1999).

Flexibility of the lower extremities was significantly improved between the initial and the final measurement. There is no doubt that the 10-minute stretching routines, performed at the end of each training session, is an adequate stimulus for improvement of the ability. A question arises: why were the corresponding significant changes not observed in the flexibility of the upper extremities? The answer may be as follows: the training stimuli applied (self-stretching) were not sufficient to cause intensive improvements of the upper limbs' flexibility. Namely, sufficient intensity is relatively easy to achieve in the stretching exercises aimed at improvements of flexibility of the lower extremities (diverse forward bends in which the trunk is brought as close as possible to the legs). But, when the shoulder girth flexibility is in question, one can hardly expect a dancer to succeed in intense stretching of his/her shoulders exclusively on his/her own. Further, it is quite possible that the anatomical reasons caused limited movement range of the shoulder joints in the participants. Such causes are hardly changeable under the influence of any kinesiological operator. Certain authors (Alter, 1996) even claim it could be risky.

Both analysed groups made a considerable progress in the measures of coordination as well, despite the fact that the HI-LO group failed to progress significantly in the variable *obstacle course with passing through and jumping over* - MBKPOP. Yet, it is hard to tell whether the numerical differences between the initial and the final measurement must be attributed to the actual improvement in coordination exclusively or to the interaction of several factors. For example, progress in the coordination measures might be a consequence of the changes in morphological characteristics (reduced subcutaneous fat tissue and enlarged lean muscle mass). All the applied tests demand locomotion and translation of the body in space. It is logical, then, to presume that the reduction of ballast mass (i.e. fatty tissue), with the simultaneous increments in active muscle mass, will cause more efficacious performance and better results. Therefore, at this moment it is hard to determine how much the results in the coordination tests were influenced by either the confirmed changes in the morphological structure of the female participants or by the actual progress in coordination itself. The same is true of the positive changes in the frequency of leg movements (*hand tapping* - MFTAN). It is quite probable that the improvements in the foot tapping were caused by the changes in the morphological structure. All the here-mentioned is corroborated by the absence of the differential effects of the two programmes on the motor space, revealed by the discriminant analysis (no significant differences between the two groups in the final measurement).

So, practically no differential influence of the step and HI-LO aerobic dance programmes was obtained either in the space of morphology or in the space of motor abilities. Comparable changes in the measures of flexibility were expected because both groups performed the same stretching routines. The changes in the measures of frequency of movements were probably caused by the changes in morphological measures (reduction of fat tissue), which were comparably equal in both groups, as demonstrated before. The differential influence in the measures of coordination did not occur, the authors consider, because both programmes (the step and the HI-LO) differ in certain manifest features that made each of them equally efficacious (but in different ways) in the process of transforming (improving) coordination. These manifest differences are:

a) The HI-LO aerobic dance programme is characterised by the movements performed in a relatively faster cadence than the step aerobics movements, but the dancers cover a larger area while performing the HI-LO routines. Both characteristics may be responsible for stronger engagement of the coordination mechanism and for, consequently, stronger transformational effects in coordination abilities of the HI-LO participants.
b) The step aerobics programme consists of a number of relatively unknown and unnatural movement patterns, like stepping on and off the platform, crossing over the top accompanied by diverse arm movements (as opposed to the HI-LO programme in which fairly known movements are performed, like walking, running, shuffle steps, cross steps and others). The fact can positively influence the development of coordination in the step aerobic dance participants.

It seems as if both experimental groups took advantage of the comparative edges of the programmes they were participating in. Therefore, no differential influence on the measures of coordination was registered.

Conclusion

The obtained results confirmed the step and HI-LO aerobic dance programmes' efficiency in producing changes in the morphological characteristics of the female participants. It can be concluded that the registered changes in the analysed morphological structure depend primarily on the intensity of the programmes (comparable physiological load of both programmes; average heart rate $HR_{hi\text{-}lo}$ = 162.43 and HR_{step} = 162.90 b/min). The manifest differences between the two programmes (step aerobics – slower cadence of both the musical accompaniment and routine performance, stepping-on and stepping-off routines are performed with a step platform, whereas hops and jumps are not performed at all; HI-LO aerobics – faster tempo of performance, routines are performed on a flat floor surface and include hops and jumps as well) do not contribute to a differential morphological effect. Under the influence of the aerobic dance programmes a set of changes occurred in the motor space, out of which the authors would like to single out the changes in flexibility and coordination in rhythm as the most important ones. The study confirmed the assumption that flexibility is one of the motor abilities that can be strongly influenced by well-chosen training operators (Alter, 1996). The positive changes in the measures of coordination and frequency of movement should be interpreted as the consequences of the interactive influence of, at least, two factors:

- Influence of changes of the morphological structure on the changes in motor manifestations;
- Actual improvements in individual motor abilities.

At this point of investigation it is hard to tell which of the two factors contributed more to the determined differences between the initial and the final measurements, especially when the expected differential influence was not obtained. Maybe further investigations with less selected samples of participants could give an answer to these questions. In that case it is probable that a greater variability of the variables obtained in the initial measurement would enable a determination of some kind of the differential influence of various programmes of aerobic dance. Consequently, the presumed differential influence would probably minimize the influence of the morphological changes on the changes in motor abilities which could be defined more objectively in that hypothetical case.

References

Alter, M. J. (1996). *Science of flexibility.* Champaign, IL: Human Kinetics.

Anderson, B. (1997). *Stretching*. Zagreb: Gopal.

Berry, M.J., Cline, C.C., Berry, C.B., & Davis, M. (1992). A comparison between two forms of aerobic dance and treadmill running. *Medicine and Science in Sports and Exercise, 24* (8), 946–951.

Blessing, D.L., Wilson, G.D., Puckett, J.R., & Ford H. T. (1987). The physiological effects of eight weeks of aerobic dance with and without hand-held weights. *American Journal of Sports Medicine, 15* (5), 508–510.

Bobo, M., & Yarborough, M. (1999). The effects of long-term aerobic dance on agility and flexibility. *Journal of Sports Medicine and Physical Fitness, 39* (2), 165–169.

De Angelis, M., Vinciguerra, G., Gasbarri, A., & Pacitti, C. (1998). Oxygen uptake, heart rate and blood lactate concentration during a normal training session of an aerobic dance class. *Journal of Sports Medicine and Physical Fitness, 38* (2), 121–127.

Garber, C.E., McKinney, J.S., & Carleton, R.A. (1992). Is aerobic dance an effective alternative to walk-jog exercise training? *Journal of Sports Medicine and Physical Fitness, 32* (2), 136–141.

Hošek-Momirović, A. (1981). Povezanost morfoloških taksona s manifestnim i latentnim dimezijama koordinacije. [Relationships of morphological taxons with manifest and latent dimensions of coordination.] *Kineziologija, 11* (IB 4), 5-108.

Kravitz, L., Cisar, C. J., Christensen, C. L., & Setterlund, S. S. (1993). The physiological effects of step training with and without handweights. *Journal of Sports Medicine and Physical Fitness, 33* (4), 348–358.

McCord, P., Nichols, J., & Patterson, P. (1989). The effect of low impact dance training on aerobic capacity, submaximal heart rates and body composition of college-aged females. *Journal of Sports Medicine and Physical Fitness, 29* (2), 184–188.

Metikoš, D., Hofman, E., Prot, F., Pintar, Ž., & Oreb, G. (1989). *Mjerenje bazičnih motoričkih dimenzija sportaša.* [Measurement of basic motor dimensions of athletes.] Zagreb: Fakultet za fizičku kulturu.

Metikoš, D., Zagorc, M., Prot, F., Furjan-Mandić, G., & Zaletel, P. (1997). Rasprava o mogućim činiteljima razvoja suvremene aerobike. [Discussion on possible factors responsible for development of modern aerobic dances.] In D. Metikoš, F. Prot. G.Furjan – Mandić & K. Kristić (Eds.), *Contemporary aerobics*: *Proceedings of International Symposium*, (pp. 4-18). Zagreb: Fakultet za fizičku kulturu, Zagrebački velesajam, Zagrebački športski savez.

Miletić, Đ. (1998). The influence of motor abilities on success in rhythmic gymnastics and dance. In *Book of Proceedings of the 3rd Congress of ECSS.* Manchester: European College of Sport Sciences.

Mišigoj - Duraković, M. (1995). *Morfološka antropometrija u sportu*. [Morphological anthropometry in sport.] Zagreb: Fakultet za fizičku kulturu.

Sekulić, D. (1997). Procjena nekih indikatora energetskog opterećenja kod izvođenja kretnih struktura u power step aerobiki. [Assessing certain indicators of energy cost of routines in power step aerobics.] In D. Metikoš, F. Prot. G.Furjan – Mandić & K. Kristić (Eds.), *Contemporary aerobics*: *Proceedings of International Symposium*, (pp. 118-120). Zagreb: Fakultet za fizičku kulturu, Zagrebački velesajam, Zagrebački športski savez.

Sekulić, D., Furjan – Mandić, G., & Kondrič, M. (2001). Influence of step aerobics programme on chosen dimensions of morphological status in males. *Kinesiologia Slovenica, 7* (1-2), 44–48.

Sekulić, D., Rausavljević, N., & Žvan, M. (2001). Characeristics and differences in the heart rate and blood lactate concentration values measured during HI-LO and Step aerobics classes. *Kinesiology, 33* (1), 27-36.

Sekulić, D. (2002). *Odnosi između nekih antropoloških čimbenika i pojedinih osobitosti psiho-fizioloških reakcija na opterećenje tijekom treninga aerobike*. [Relationships between some anthropological characteristics and psycho-physiological response during training of aerobics.] (Unpublished doctoral dissertation, University of Zagreb), Zagreb: Kineziološki fakultet.

Shimamoto H., Adachi, Y., Takahashi, M., & Tanaka, K. (1998). Low impact aerobic dance as a useful exercise mode for reducing body mass in mildly obese middle-aged women. *Journal of Applied Human Science, 17* (3), 109-114.

Zagorc, M., Zaletel, P., & Ižanc, N. (1996). *Aerobika*. [Aerobics. In Slovenian.] Ljubljana: Fakulteta za šport.

Željković, R., & Metikoš, D. (1997). Kineziološka obilježja osnovnih kretnih struktura u aerobici. [Kinesiological attributes of basic movement structures in aerobic dance.] In D. Metikoš, F. Prot. G.Furjan – Mandić & K. Kristić (Eds.), *Contemporary aerobics*: *Proceedings of International Symposium*, (pp. 178-181). Zagreb: Fakultet za fizičku kulturu, Zagrebački velesajam, Zagrebački športski savez.

PROMJENE U MOTORIČKIM I MORFOLOŠKIM MJERAMA POD UTJECAJEM PROGRAMA HI-LO I STEP AEROBIKE

Sažetak

Uvod

Programi suvremene aerobike danas su jedan od najpopularnijih oblika rekreativnog tjelesnog vježbanja. U dosadašnjim istraživanjima autori su ukazali na pozitivne promjene pojedinih dimenzija antropološkog statusa vježbačica pod utjecajem tretmana suvremene aerobike (primjerice, Kravitz i sur., 1993). Međutim, promjene u motoričkim sposobnostima rijetko su se istraživale. Ovaj rad pokušao je ukazati na potencijalne diferencijalne učinke programa step (N = 24) i hi-lo aerobike (N = 23), ali i analizirati promjene u morfološkim (varijable za procjenu voluminoznosti i debljine kožnih nabora) i motoričkim mjerama (koordinacija, fleksibilnost, frekvencija pokreta) u sudionica programa.

Metode

Ukupan tretman sastojao se od 25 pojedinačnih treninga aerobike (3 puta tjedno). Svaki pojedini trening uključivao je: *cardio* sekciju koja je sadržavala eksperimentalne programe aerobike (35 minuta), vježbe snage (15 minuta) i vježbe istezanaj (10 minuta). Za obradu rezultata korištena je diskriminacijska analiza, kojom je utvrđena značajnost razlika između skupina u motoričkom i morfološkom prostoru u inicijalnom i finalnom mjerenju. Analizom varijance utvrđene su razlike između inicijalnog i finalnog mjerenja za svaku pojedinu skupinu.

Rezultati, rasprava i zaključak

Diskriminacijskom nalizom nije utvrđena značajnost razlika u motoričkom prostoru u inicijalnom mjerenju (Wilks lambda = 0.45; p > 0.05) ni u finalnom mjerenju (Wilks lambda = 0.42; p > 0.05). Razlike među skupinama nisu uočene ni u morfološkom prostoru, ni u inicijalnom (Wilks lambda = 0.64; p > 0.05) ni u finalnom mjerenju (Wilks lambda = 0.76; p > 0.05).

Analiza varijance ukazala je na značajne promjene u morfološkim varfijablama i to u pogledu smanjenja kožnih nabora, ali su izostale značajne promjene u mjerama opsega tjelesnih regija. Iste su promjene uočene i u eksperimentalnoj skupini koja je provodila program step aerobike, kao i u eksperimentalnoj skupini koja je provodila program hi-lo aerobike.

U motoričkim su varijablama značajna poboljšanja rezultata uočena u mjerama fleksibilnosti donjih ekstremiteta (u obje grupe), ali ne i u mjerama fleksibilnosti ramenog pojasa. Te se promjene mogu pripisati učincima vježba istezanja koje su se izvodile na kraju svake trenažne jedinice. Nadalje, u mjerama frekvencije pokreta također je došlo do značajnih poboljšanje rezultata, što se vjerojatno može pripisati utjecaju smanjenja potkožnog masnog tkiva na motoričke manifestacije koje se izvode u testiranju frekvencije pokreta. U mjerama koordinacije, a naročito u mjerama koordinacije u ritmu također su uočena značajna poboljšanja rezultata koja su, prema mišljenju autora, nastala zbog interakcijskog djelovanja slijedećih faktora:

- utjecaja promjena morfološke strukture ispitanica na promjene u motoričkim manifestacijama koordinacije u ritmu;
- stvarnog napretka u koordinaciji u ritmu.

Naime, vrlo je vjerojatno da su promjene u navedenim motoričkim sposobnostima dijelom uvjetovane prvim, a dijelom drugim faktorom. U ovom trenutku ne može se utvrditi koliko je koji faktor doprinio utvrđenim razlikama između inicijalnog i finalnog mjerenja, tim više što je diferencijalnost utjecaja i u ovom pogledu izostala. Odgovore na ova pitanja mogla bi dati daljnja istraživanja koja bi se provela na manje selekcioniranim uzorcima ispitanica. U tom slučaju moguće je da bi veći inicijalni varijabilitet rezultata u pojedinim mjerama omogućio definiranje određenog diferencijalnog utjecaja. U tom bi slučaju bilo moguće, u određenoj mjeri, eliminirati utjecaj morfoloških promjena na promjene motoričkih sposobnosti i time objektivnije definirati promjene u motoričkom prostoru, nastale pod utjecajem različitih programa aerobike.

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