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STUDENTS' – INSTRUCTORS' PHYSIOLOGICAL RESPONSES DURING STEP AEROBIC EXERCISE

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Abstract. This study tried to examine some physiological response variables (PER) of step aerobics exercise (S-A) for a group of aerobic instructors (n=10) and their students (n=16). All instructors trained an equal 30-min S-A program, for a group of students. Heart rate (HR) was monitored continuously, and the average HR and %HRmax of the first half (min 1st – 15th), and the second half (min 16th – 30th) of the session was calculated. Blood lactate (BL) was measured in the 15th and 30th min of the session. Instructors and students differentiated significantly in age, aerobic dance experience, HR and %HRmax between the15th and 30th min of the S-A session (t-tests AGE: 12.60, $p<0.001$; Experience: 6.22, $p<0.001$; HR_{16-30}: 2.48, $p<0.05$; $\%HRmax_{16-30}$: 3.2, $p<0.01$). Students, but not instructors, tended to have lower HR during the second half compared to the first half of the S-A (t test: 2.3, $p<0.05$). BL for both groups increased from the first to the second half of the S-A ($p<0.05$). HR seemed to fail to monitor training intensity during S-A for the both groups, because of the motor-learning process (characteristic for students), and verbal cueing (instructors). Finally, it seems that previously reported health related problems of aerobic dance instructors are not related to the magnitude of the acute physiological stress during single session, but more likely to the disproportional frequency of the exercises (6-9 sessions weekly).

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Key words: Experts – Novices – Recreation - Motor-skill - Correlation

Introduction

Apart from the approved transformational efficacy of the aerobic-dance (AD) on different physical fitness and health indices [4,15,16,19], one of the main reasons for the popularity of AD probably are - instructors. From the numerous

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recreational-training activities, it is very hard to find one, where the instructor is as engaged as in AD. But, as professionals, AD instructors train 6-9 one-hour lessons weekly. Almost all authors who investigated and reported certain health-related problems of AD are of opinion that the physiological (but also psychological) training-load of instructors is pronounced. Garrick *et al.* [11] investigated the health problems associated with AD. Instructors were twice as likely to be injured as students. In the study of Olson *et al.* [21] 40% of the sampled instructors indicated a previous experience with eating disorders (23% - bulimia and 17% - anorexia). Toit du and Smith [27] reported a rate of AD instructors injury of 77%, and very similar rates are presented in the paper of Komura *et al.* [14]. Mainly, it is believed that most injuries occurring in AD resulted from the high impact manoeuvres and high training intensity. But, precise data about the physiological load (physiological exercise response – PER) of the AD instructors is still insufficient. Generally, there is a lack of studies that examine the physiological response parallel for the instructors and for the students. If we were able to objectively determine and compare the training workload of the AD instructors and students, there would be a greater chance of acting preventively to outwit defined health related problems.

Step-aerobics (S-A) is one of the most popular forms of AD [24,25]. Although published data profiling the type and frequency of injury exclusively associated with S-A is not presently available, it is obvious that characteristic manoeuvres in S-A, may altogether produce a certain set of injuries.

The aims of the present study were: a) to define characteristic physiological exercise response (PER) to S-A, parallel for instructors and their students; b) to examine some of the potential predictors of the PER induced by S-A, parallel for instructors and their students.

Materials and Methods

Subjects: After informed consent was obtained, the sample of subjects was divided in two groups. The first group consisted of current AD instructors (INSTR; n=10; all females) who had been teaching at least 2 years, performing 6-9 sessions weekly. The second group consisted of regular AD students (STUD; n=16; all females) with at least a half-year experience in AD, performing 2-3 sessions weekly.

Variables: The sample of subjects were tested on: AGE – age; BW - body weight; BH - body height; EXPER – aerobic dance training experience and aerobic work indices: BEEP – 20 m multistage field test [7,12] and VO_{2max} - maximal oxygen consumption. In all 10 instructors and 16 randomly selected students (see later text) VO_{2max} was measured, using the RM-300 and AE280 automatic gas-collection systems (Minato Medical Sci. Co, Ltd). The instruments were calibrated with a reference gas prior to each test. Minute ventilation was continuously sampled on a one-minute basis, during the incremental treadmill test to voluntary exhaustion using the modified Bruce protocol [17]. Concentrations of oxygen and carbon dioxide in expired gases were collected each minute and analyzed. VO_{2max} was determined as the highest VO_2 value obtained when respiratory exchange ratio was ≤ 1.

As a physiological exercise response (PER) measures following variables were used: HR_{1-15} , HR_{16-30} - average HR in the first half (1^{st} to 15^{th} min), and in the second half (16^{th} to 30^{th} min) of the session (in $b \cdot min^{-1}$); $\%HR_{1-15}$, $\%HR_{16-30}$- percentage of the maximum HR for the first half, and for the second half of the session (in %); BL15, BL30 - blood lactate concentration measured in 15^{th} min (half), and in the 30^{th} min (end) of the session (in $mmol \cdot l^{-1}$). A 25-µl sample of arterialised capillary blood was collected in a 100-µl capillete from a digit puncture. The sample of whole blood was analysed using a Boehringer Manheim's Accusport lactate analyser - Germany [3,9]. HR was permanently monitored using the Accurex-plus monitors - Polar Electro Oy, Finland [17]. Data were downloaded at a later stage to a computer via an interface lead, and transferred in numeric format for further analysis. The percentage of the maximal HR [20] was calculated using the formula:

$\%HR_{1-15}=100 \cdot HR_{1-15} (220 - AGE)^{-1}$; and $\%HR_{16-30}=100 \cdot HR_{16-30} (220 - AGE)^{-1}$

HR and BL measurement procedure and calculations are presented in Fig. 1.

Experiment: The subjects were asked to refrain from large meals, or drinks containing caffeine and alcohol, and from smoking for the 2 h preceding the test. The instructors learned and trained the step-session in advance, a day before the experiment, but students had no preliminary information about the characteristics of the program. Complete session consisted of the 5 min warm-up (low-impact movement patterns) and 30 min S-A. The warm-up was not included in the HR measurement and calculations. Since all subjects performed identical S-A choreography (controlled by third author), using the step-platform of the equal dimensions (20 cm high "Reebok" step-platform), same type of music (music tempo: 125-130 beats/min), in the same gym (23-25°C), at the same time of a day (17.00-19.00), there is no need for the precise presentation of the choreography. The first instructor trained the session for the four students. Next day, the second instructor trained the same program for next four students, and so on. Following the same pattern, 40 students participated in the experiment (each of 10 instructors trained 4 students), but the data from 16, randomly selected students (1-2 from each class), were included in the present study, to avoid the disproportional number of the subjects in each group (in final: 10 INSTR vs. 16 STUD). VO_{2max} measurement was performed a day after S-A.

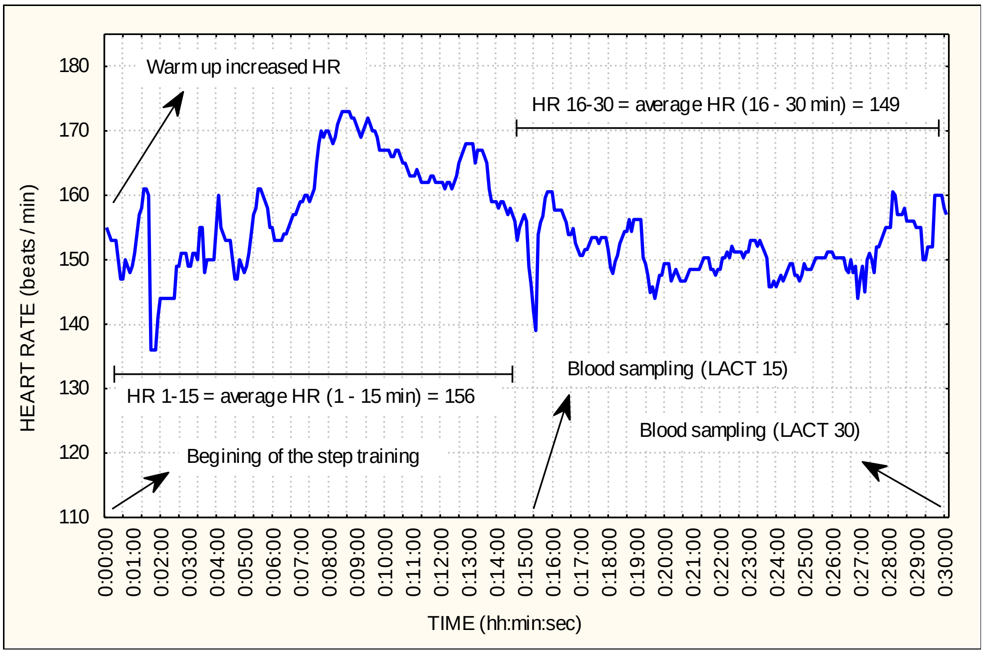

Fig. 1
Presentation of the heart rate curve (one randomly selected subject), calculations of the heart rate values (HR_{1-15} ; HR_{16-30}), and blood sampling timings

Data processing: Statistical analysis was carried out using Statsoft's Statistica version 6.0. Following the calculations of descriptive statistics (Means, Standard deviations), independent t-tests were used to compare the descriptive characteristics of the groups (INSTR vs. STUD). Dependent t-tests were used to compare the descriptive characteristics within the groups, for repeated measurements of the same variables (HR, %HR, BL). Correlations between variables were defined using the Pearson's r – coefficient, separately for the INSTR, as well as for the STUD. All coefficients considered significant at $p<0.05$.

Results

Table 1
Descriptive statistics

	Instructors		Students		t-test
	Mean	SD	Mean	SD	
Body height (cm)	172.80	5.77	169.92	4.75	1.39
Body weight (kg)	62.55	4.51	62.71	7.80	-0.06
Age(year)	26.20	1.40	21.06	0.68	12.60*
Experience (year)	6.60	1.08	3.13	1.54	6.22*
Beep (level)	7.59	0.61	7.96	1.39	-0.80
VO_{2max} ($ml \cdot kg^{-1} \cdot min^{-1}$)	38.45	1.97	39.73	4.86	-0.93
HR_{1-15} ($b \cdot min^{-1}$)	157.01	12.83	162.98	17.94	-1.23
HR_{16-30} ($b \cdot min^{-1}$)	160.58	15.28	151.18	13.82	2.48*
HR_{1-30} ($b \cdot min^{-1}$)	158.66	14.55	156.55	15.21	0.31
$\%HR_{1-15}$ (%)	81.00	6.50	82.00	9.10	-0.27
$\%HR_{16-30}$ (%)	82.80	7.70	73.05	7.20	3.20*
Blood lactate 15 ($mmol \cdot l^{-1}$)	3.03	1.12	2.81	1.42	0.42
Blood lactate 30 ($mmol \cdot l^{-1}$)	4.56	2.07	4.52	1.94	0.05

*$p<0.05$

Experience – aerobic dance experience; Beep – multilevel aerobic endurance test; HR_{1-15}- aggregated heart rate for the first half (1st to 15th min) of the session; HR_{16-30} – aggregated heart rate for the second half (16th to 30th min) of the session; $\%HR_{1-15}$ - average percentage of the maximum heart rate for the first half of the session; $\%HR_{16-30}$ –average percentage of the maximum heart rate for the second half of the session; BL15 – blood lactate concentration measured in the 15th min (half) of the session; BL30 – blood lactate concentration measured in the 30th min (end) of the session

Significant differences between INSTR and STUD are observable for age, experience and two PER variables (aggregate HR values: HR_{16-30} and $\%HR_{16-30}$).

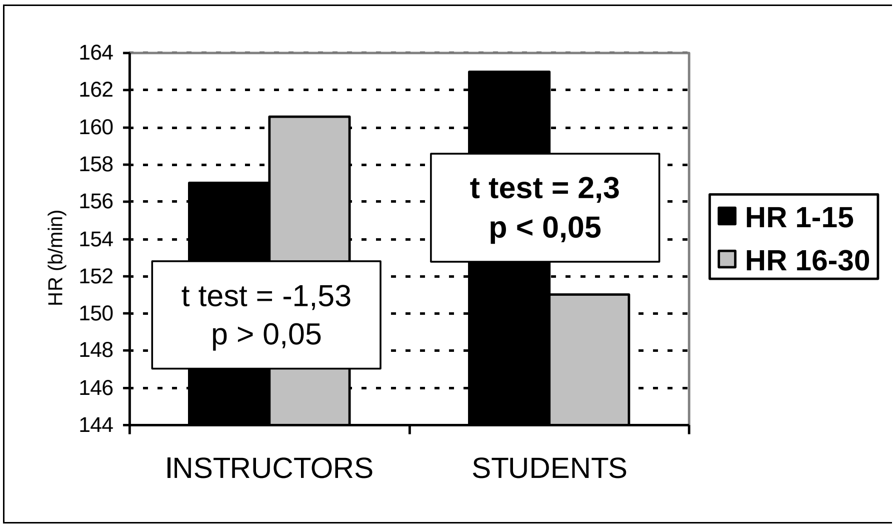

Fig. 2
Aggregated heart rate values (mean average heart rate for the first half of the step aerobic session – HR 1-15; mean average heart rate for the second half of the step aerobic session - HR 16-30), dependent samples t-tests (t test value – t test; level of the significance – p)

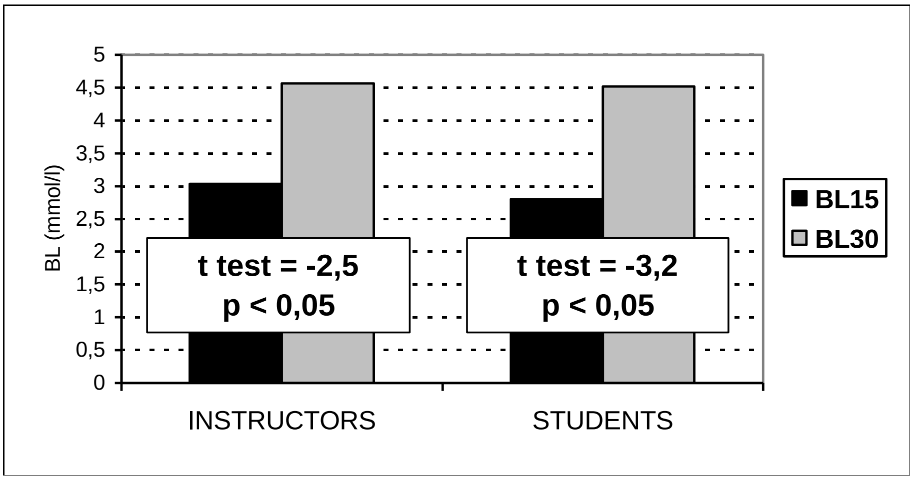

Fig. 3
Blood lactate values (mean blood lactate-concentration value sampled in the 15th – BL15, and 30th minute of the step aerobic session – BL30), dependent samples t-tests (t test value – t test; level of the significance – p)

Within PER variables measurements, significant differences are established for the variable BL (significant increase for the INSTR and STUD); and the aggregated HR (significant decrease for the STUD).

Table 2
Linear correlation (Pearson's r coefficients) between variables

Instructors (n=10)	Body height	Body weight	Age	Experience	Beep	VO_{2max}	Blood lactate 15	Blood lactate 30	HR_{1-15}	HR_{16-30}
Body weight	0.67*									
Age	-0.13	-0.72*								
Experience	0.00	0.10	-0.01							
Beep	-0.56	-0.53	0.34	0.28						
VO_{2max}	-0.59	-0.62	0.40	0.31	0.88*					
Blood lactate 15	0.48	0.40	-0.08	-0.16	-0.27	-0.35				
Blood lactate 30	0.06	0.22	-0.27	-0.37	-0.30	-0.37	0.43			
HR_{1-15}	0.78*	0.45	-0.20	-0.39	-0.75*	-0.73*	0.53	0.09		
HR_{16-30}	0.67*	0.66*	-0.35	-0.17	-0.55	-0.49	0.63	0.08	0.88*	
$\%HR_{1-15}$	0.78*	0.39	-0.11	-0.40	-0,73*	-0.67*	0.54	0.07	1.00*	0.86*
$\%HR_{16-30}$	0.68*	0.67*	-0.29	-0,18	-0.54	-0.51	0.64	0.06	0.89*	1.00*

Students (n=16)	Body height	Body weight	Age	Experience	Beep	VO_{2max}	Blood lactate 15	Blood lactate 30	HR_{1-15}	HR_{16-30}
Body weight	0.50*									
Age	-0.20	0.07								
Experience	-0.11	-0.19	0.25							
Beep	0.12	-0.11	-0.08	-0.02						
VO_{2max}	0.10	-0.07	-0.08	-0.04	0.84*					

Blood lactate 15	-0.31	-0.01	-0.17	-0.38	-0.06	-0.08				
Blood lactate 30	-0.47	-0.20	-0.12	0.07	-0.50*	-0.55*	0.52*			
HR $_{1\text{-}15}$	-0.06	0.52*	0.14	-0.15	-0.55*	-0.61*	0.19	-0.03		
HR $_{16\text{-}30}$	-0.59*	-0.03	0.15	0.26	-0.55*	-0.63*	0.51*	0.51*	0.46	
%HR$_{1\text{-}15}$	-0.07	0.52*	0.16	-0.14	-0.55*	-0.62*	0.18	-0.04	1.00*	0.44
%HR$_{16\text{-}30}$	-0.59*	-0.03	0.18	0.27	0.54*	-0.58*	0.50*	0.51*	0.16	1.00*

(*p< 0.05)

Discussion

As presented in Table 1, INSTR and STUD do not significantly differ in aerobic work-capacity indices (BEEP and VO_{2max}). We could expect that professional instructors, as well-trained persons, achieve a higher qualitative level in this measure of physical-fitness status, compared to AD participants. However, it might be that instructors do not adequately attend to overall aerobic-endurance workout and possibly become set in their routines so that only a specific number of muscles/motor units are repetitively used at the relatively constant training volume, which does not ensure adequate training-load for further aerobic endurance improvement. Although our results may seem surprising, previous studies brought out very similar conclusions and possible explanations [5]. It is interesting that INSTR and STUD are significantly different in one PER variable only ($HR_{16\text{-}30}$, followed with $\%HR_{16\text{-}30}$). According to those parameters, INSTR tend to be considerably acutely physiologically more loaded than their students. It is even more intriguingly if we observe that instructor’s HR slightly increase (non-significant) toward the end of the session, while students' HR significantly decrease, from the first half ($HR_{1\text{-}15}$) to the end ($HR_{16\text{-}30}$). These values are followed with %HRmax changes, because of the relatively small age-differences between the two analysed groups. The reasons for the mentioned HR changes (within groups) and differences (between groups) can be stated as follows. The students are regularly unfamiliar with S-A choreography. Therefore, in our experiment they didn’t know it in advance, as aerobic instructors did. It is well known, that absence of knowledge of certain motor-skills results in irrational and non- effective performing of the motor-program which defines the high physiological response [23]. According to Guthrie (after 23), improved skill proficiency is reflected by increases in certainty, decreases in energy expenditure, and sometimes decreases in movement time. In the case of the S-A, the most interesting is "decrease in energy expenditure". Consequently, the decrease of energy expenditure probably means - the reduction and elimination of unwanted or unnecessary movements, but also - rationalization of the execution of movement patterns – AD (S-A) elements. But, the mental demands of the task - directly influence the HR (22). So, decrease of mental demands is naturally followed by HR decrease. Decrease of mental demands is characteristic for students during the second half of (any) S-A session, because motor - learning process is (generally) finished during the first half of the training session.

But, decrease of the HR for the INSTR is not observable, as it is observable for the STUD. The reason can be found in INSTR's advance-knowledge of the class patterns, which determines the low mental demands. But, not to forget - instructors are high-skilled individuals. According to Fitts and Posner (after 23) high – skilled individuals are persons at an autonomous stage of the motor-learning process, which is characterized by relatively stable energy expenditure. Probably, the stable energy expenditure, completed with stable mental demand, defines - relatively stable HR values (in our case). Considering all said we have to explain the higher HR-values of the instructors, compared to students. A problem is – unbalanced and interrupted breathing. That interrupted and non-rhythmical breathing is caused by one-way verbal communication between INSTR and STUD known as "verbal cueing". During the training session, aerobic instructors continuously communicate with participants, while explaining the choreography, step-patterns and space-directions, which makes breathing at least – difficult, constantly burdens cardio-respiratory system and elicits HR over the objectively and metabolically required levels [19,26]. BL values confirms all afore stated. BL (Table 1, Fig. 3) increases significantly for both groups (INSTR and STUD). There are no differences between groups in the BL measures, not at the first half of the session (BL15), nor at the second one (BL30). The reason for the BL increase can be found in the relatively long training session (30 min), but also in the HR values, 80 $\%HR_{max}$ for both groups approximately, which should be the upper limit for the maximal lactate steady state. But, 80% of the HR_{max} is average parameter. Some subjects performed the training session at higher intensity (up to 95% HRmax), which naturally, because of the exponential character of the lactate-curve [11], increases total-average blood lactate value above the anaerobic threshold $\%HR_{max}$ level (80%).

It is interesting that there are no significant differences between groups in BL values, although it could be expected, according to HR_{16-30} values (previously discussed). It might be that instructors' HR_{16-30} values (significantly higher than ones observed in STUD group) is not an objective indicator of the physiological stress. The current results suggest that HR couldn't be considered as a satisfactory guide for determining training intensity for aerobic instructors, because of the characteristic HR-increasing-effect of the previously explained - verbal cueing. Verbal-cueing might seem as a trivial problem, but it is not rare that aerobic instructors experience even vocal fatigue and are at risk for the development of vocal fold pathology [28]. Because of this disproportion of HR and training intensity, for the INSTR group, lactate concentration does not follow increase of the HR. It led to no significant differences in BL_{30}, between INSTR and STUD, although such differences could be expected considering the significant differences in HR_{16-30} (Table 1, Fig. 2). HR measurement, as a PER measure, is the most frequently used method, because of the relative simplicity. In previous researches, HR seemed to fail to monitor the metabolic intensity during AD [2,8,24] and it is very possible that the HR is not a completely valuable parameter of the intensity monitoring for AD, as it is for some other training activities, like cycling, or running [13]. However, blood lactate concentration (BL) could be considered as a reliable and valid measure for monitoring physiological training load during AD class, because, it is affected mostly by physiological demands [24,25]. According to the correlation matrix (Table 2), for aerobic instructors, HR measures are directly positively correlated to BH and BW. Elementary, HR is probably influenced by a total body weight (BW), and the correlation between BH and HR measures is a typical suppressor-effect (because BH is correlated with BW). Aerobic capacity indices (BEEP and VO_{2max}) are negatively correlated with HR_{16-30}, but we suppose that the true-decreasing effect, can be found in the combination of the aerobic endurance capacity and characteristic aerobic-training-experience (EXPE), which is (for the INSTR group), although not significantly, negatively correlated with all PER measures (lactate and HR variables). For the STUD, significant positive correlation between BW and HR measures in the first half of the session could be attributed to the negative influence of the excess body weight (body fat mainly) on the HR dynamics [25], especially because of the characteristic motor-learning (explained before). But, in the second part of the session, when characteristic motor-program is stabile and learned, BH is naturally negatively correlated with the HR measures. In short, since all subjects performed the S-A using the same bench height (see Experiment) - taller subjects performed the lower characteristic "step-up" movement pattern [25]. One should argue that the same arguments should be used for INSTR, but authors are of opinion that the same logic of the correlation is not appropriate for INSTR because of the "cueing" problem (previously explained).

Negative correlation between aerobic capacity measures (BEEP and VO_{2max}) and all PER variables, for the group of participants do not surprise us. The higher aerobic capacity is - the better prolonged-exercise-tolerance is [1,6]. Therefore, the higher aerobic capacity is – the lower PER values are (in our case - HR and BL). The main reason for the absence of significant correlation between the same variables (aerobic work indices and PER variables) for the INSTR group can be found in a small number of degrees of freedom (df), which are determined by a relatively small number of INSTR subjects ($df_{instructors}$ =9; $df_{students}$=15).

In conclusion, according to the results of this study, aerobic instructors, experience equal physiological demands during S-A as their students. Finally, it seems that the previously reported health related problems of AD instructors are not related to the magnitude of the acute physiological stress during single AD training, but more likely to the disproportional frequency of the exercises. Consequently, instructors included in here presented study, train 6-9 sessions weekly, which is a very generative basis for the different over-training symptoms, which can lead to the previously mentioned health related problems of the instructors.

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