Oxygen uptake during of modern dance class, rehearsal and performance

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Oxygen uptake during of modern dance class, rehearsal and performance

Abstract

The aim of the present study was to examine whether the workload, expressed in oxygen uptake and heart rate, during dance class and rehearsal prepared the dancer for performance. Previous research on the demands of class and performance has been affected by equipment limitations and could only provide limited insight into the physiological demands placed on the dancer. The present study noted that dance performance had significantly greater mean oxygen uptake and heart rate than noted in both class and rehearsal ($P<0.05$). Further analysis noted that during class and rehearsal heart rates were rarely within the aerobic training zone (60-90%HR_{max}). Dance performance placed a greater demand on the aerobic and anaerobic glycolytic energy systems than seen during class and rehearsal, which placed a greater emphasis on the ATP-CP system. Practical implications suggest the need to supplemental training within dance companies to overcome this deficit in training demand.

Keywords:

Training demand, intervention strategies, telemetric gas analysis

Introduction

The physiological classification of contemporary dance is an area of contention among dance professionals. This is mainly due to the fact that dancers' see themselves as artists and not athletes and that physiological training is only a means to an end, that being the search for the aesthetic. Cohen [1] noted "…. dance is ….. quick bursts of energy …. interspersed with steady state activities" which seems to suggest a form of intermittent exercise [2]. The aerobic component of dance is very limited due to the structure of the primary training forum, the dance class. The dance class has for centuries focused on increasing the dancers' movement vocabulary, improving musicality, phrasing, developing creativity and expression; in summary the focus has been on the mastery of the art form [3].

During dance class the warm-up, either at the barré, on the floor or in the centre (depending on the style of the class) aims to increase whole body and muscle temperature, increase joint articulation and improve limb alignment. The work time more continuous although the intensity is low. The "centre" phase of the class is generally at a higher intensity but the actual exercise periods are shorter (30-45 seconds) with longer recovery periods [4]. The size of the class, the level of the dancers and the sequence length often determine the length of recovery time.

Previous research has noted a disparity between the level of dancer and the oxygen requirements of class [4]. Wyon *et al* [4] reported that undergraduate and professional dancers spent the majority of the class between 10-25 $ml.kg.^{-1}min.^{-1}$ (83.8% and 83.5% respectively) and heart rates were below 140 $b.min^{-1}$ for 78% and 74% of the class respectively. Data on performance demands has been limited for a number of reasons. The main reason being a lack of suitable equipment to collect the relevant data with Douglas bags proving too cumbersome, thereby preventing or restricting movement [5]. A number of studies have used heart rate monitors to collect data during performance and then extrapolated the equivalent oxygen demands from HR-$\dot{V}O_2$ data collected during a graded exercise test [6, 7]. Recent research has shown this method to be flawed as two different types of exercise were being undertaken by the subjects, steady state (graded exercise test) and intermittent (dance). The HR-$\dot{V}O_2$ relationship between these two forms of exercise is good a high workloads but below 120 $b.min^{-1}$ the limits of agreement indicate that this type of extrapolation is severely flawed [8]. This would not be a concern if the mean HR during class were high (e.g. 170 $b.min^{-1}$), as in many team sports. However, mean heart rates during class have been reported to be 117 $b.min^{-1}$ [4]. Another problem with performance data is that in many cases only parts of the performance were monitored, which does not provide a full understanding of the performance demands. Schantz and Astrand [5] also noted that because Douglas bags had been used to collect the expired gas, only mean data were available. Recently, lightweight portable gas analysers have become available that allow the measurement of oxygen uptake *in situ*, thereby providing more accurate assessment of the physiological demands of specific activities. The aim of the present study was to examine the oxygen demands of class, rehearsal and performance within modern dance by direct analysis via a telemetric gas analyser.

Method

Ethical approval was granted by the University of Roehampton Surrey and 40 dancers volunteered for the study. Their mean (±sd) height, weight and age were 166.8cm (±10.6), 62.9kg (±8.8) and 22yrs (±3.7), respectively. Participants signed an informed consent document and were familiarised with the equipment before the test. Each dancer was tested in situ at their place of work. The dancers were normally exposed to a number of teachers taking their classes; therefore a variety of classes were monitored at each establishment encompassing the different teaching styles. The teachers and artist directors taking the sessions were asked not to modify the content due to data being collected. Dress rehearsals were used instead of actual performances due to the gas analyser preventing some choreographic movements and also the fact that the machine produced a noise. Half an hour before the start of data collection the dancer was fitted with a heart rate monitor and telemetric gas analyser [9]. The dancer was told that the apparatus could be removed at any stage either to drink water or to terminate the test. At the start of the test “mark” was pressed on the portable unit and at any stage throughout the test when the apparatus was removed. Each test was filmed in order to calculate the work-to-rest ratio.

To aid comparison the data were grouped according to the percentage time spent in specific bands ($5 ml.kg.^{-1}min.^{-1}$ for oxygen data and $10\ b.min^{-1}$ for heart rate data). Differences between the groups were tested for significance using ANOVA with post hoc analysis using Tamhane’s T2. The level of significance was set at 95%.

Results

Mean values for the different aspects of dance performance can be seen in Table 1. Significant differences in oxygen requirement for the whole class ($p<0.01$), the warm-up ($p<0.05$) and centre ($p<0.01$) were observed between the sexes (Table 2; Fig. 1). Neither sex showed any significant differences in the observed variables between the different class styles (Graham-based, Limón-based and Cunningham-based).

Figure 1 Gender differences in percentage time spent at specific oxygen costs during class

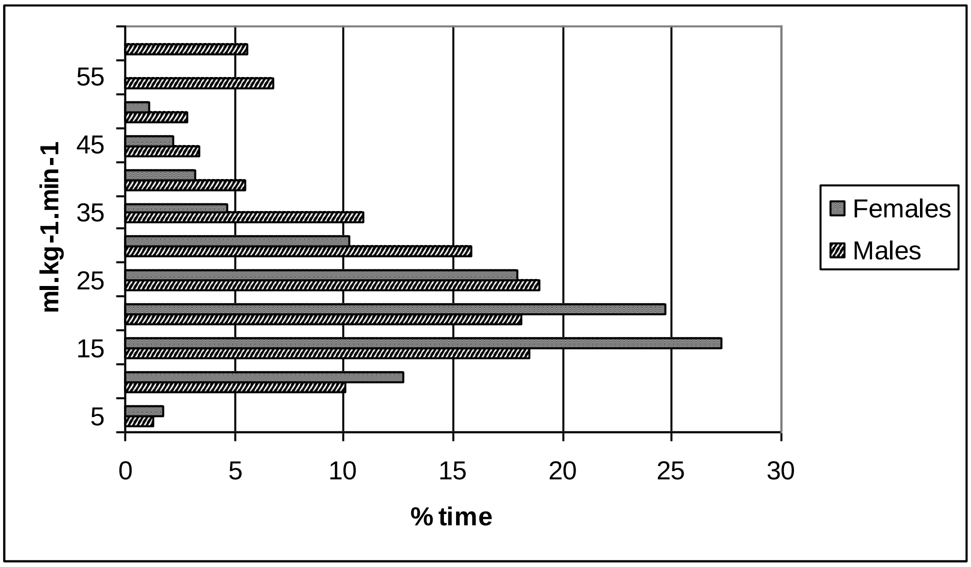


Table 1 Mean data for class, rehearsal and performance

		Mean $\dot{V}O_2$ (ml.kg.$^{-1}$min.$^{-1}$)	Mean HR (b.min^{-1})	Mean Energy Expenditure (kcal.min^{-1})
Class	Male	22.06 $\pm$5.86	118 $\pm$15.24	6.67 $\pm$1.95
	Female	17.42 $\pm$2.75	117 $\pm$11.58	4.73 $\pm$0.81
Rehearsal	Male	17.19 $\pm$3.28	112 $\pm$6.44	5.93 $\pm$1.33
	Female	10.17 $\pm$6.63	108 $\pm$26.31	2.63 $\pm$1.87
Performance	Male	24.85 $\pm$5.83	134 $\pm$14.28	8.49 $\pm$2.58
	Female	23.34 $\pm$3.83	132 $\pm$9.76	6.67 $\pm$1.05

There were no significant differences in the measured variables between genders for performance and rehearsal data. No significant differences were noted in the observed variables between class and rehearsal. Analysis between class and performance reported significant differences in mean heart rates ($p<0.01$), mean oxygen consumption ($p<0.01$), the number of heart rate peaks >180 $b.min^{-1}$, and the percentage work time ($p<0.01$). Male subjects reported significant differences in mean heart rate ($p<0.05$) and the number of heart rate peaks >180 $b.min^{-1}$ ($p<0.05$); whilst female subjects reported significant differences in the mean oxygen requirement ($p<0.01$), the number of heart rate peaks ($p<0.05$) and the percentage work time ($p<0.05$). Mean oxygen requirement and heart rate data from rehearsals were significantly lower than that observed during performance ($p<0.01$). Figures 2 and 3 demonstrate the variation in oxygen demand and heart rates between the designated tests.

Table 2 Class: Mean data for warm-up and centre sections

		Mean $\dot{V}O_2$ ($ml.kg.^{-1}min.^{-1}$)	Mean HR ($b.min^{-1}$)	Mean Energy Expenditure ($kcal.min^{-1}$)	Percentage work time (%)
Warmup	Male	18.65 ±4.72	108 ±19.72	5.98 ±2.09	80.93 ±5.32
	Female	14.67 ±3.87	107 ±16.6	3.97 ±0.82	74.83 ±7.88
Centre	Male	24.78 ±7.07	126 ±14.63	8.06 ±2.77	46.45 ±10.07
	Female	19.39 ±3.24	122 ±12.58	5.67 ±1.08	41.85 ±13.28

Figure 2 Percentage time spent at specific oxygen costs during class, rehearsal and performance

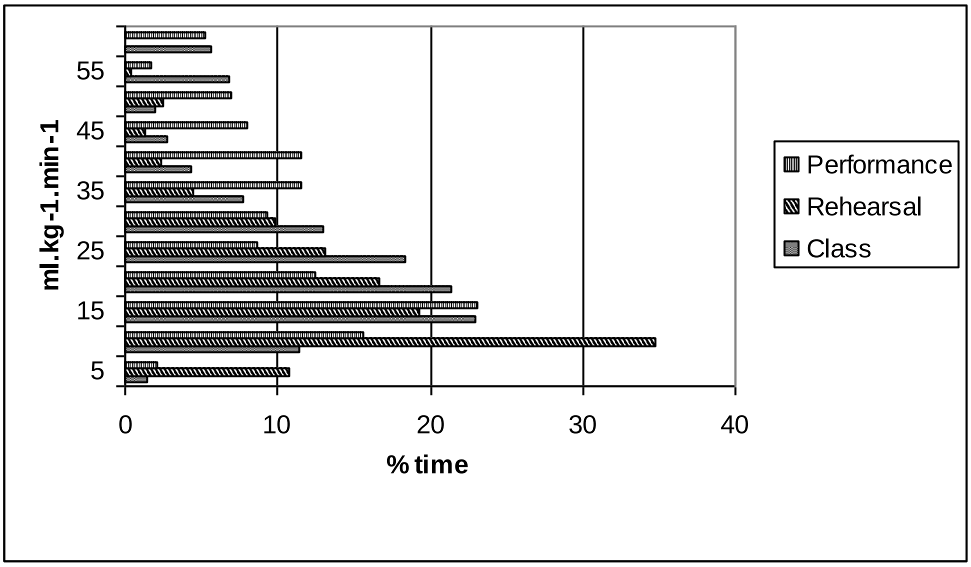
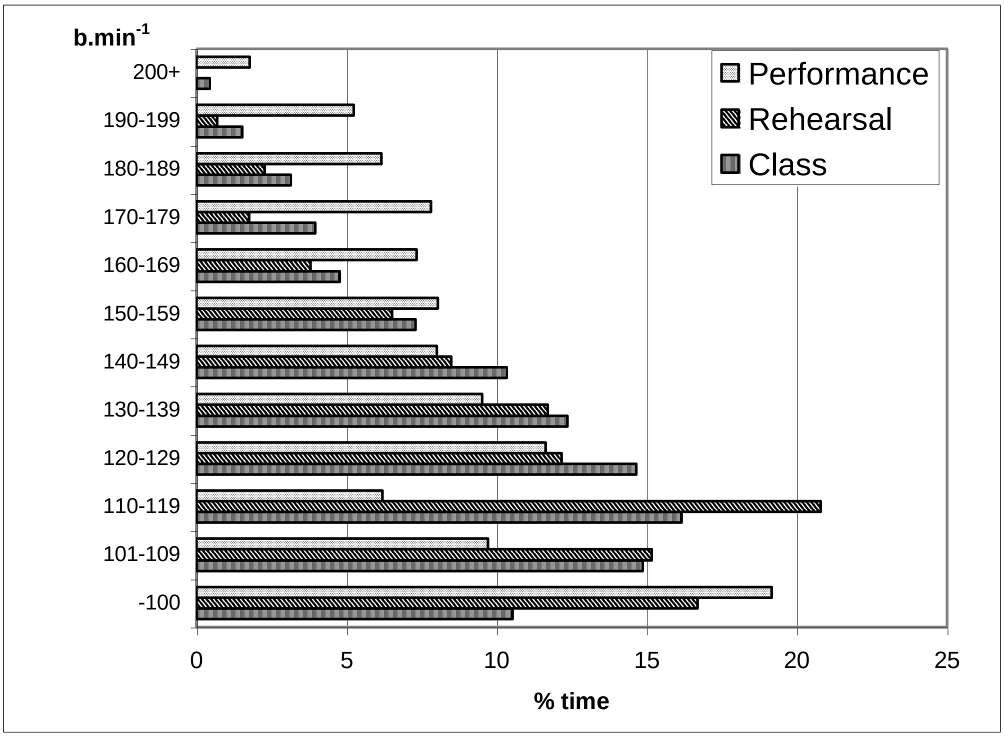


Figure 3 Heart rate bandwidths for class, rehearsal and performance



Training Zones

The mean percentage time spent in specific heart rate and oxygen consumption bands were calculated for each group. Oxygen consumption for the majority of class (Fig. 1) was between 10-25 ml.kg.$^{-1}$min.$^{-1}$ for all groups (university 83.8%, graduate 69.4%, professional 83.6%). The university and professional dancers spent the majority of class between 100-140 b.min^{-1} (77.9% and 74.3% respectively) (fig. 2). The graduate dancers spent the majority of time within a higher bandwidth, 71.1% between 120-160 b.min^{-1}. Graduate dancers spent the greatest amount of time above 120 b.min^{-1} (86.7%), whilst university and professional dancers spent 62.5% and 51.2% respectively above 120 b.min^{-1}. Figures 4 and 5 provide examples of heart rate during class and performance with approximate aerobic training zones indicated (60-90% HR_{max} [10]).

Figure 4 Time spent in Aerobic Training Zone during class

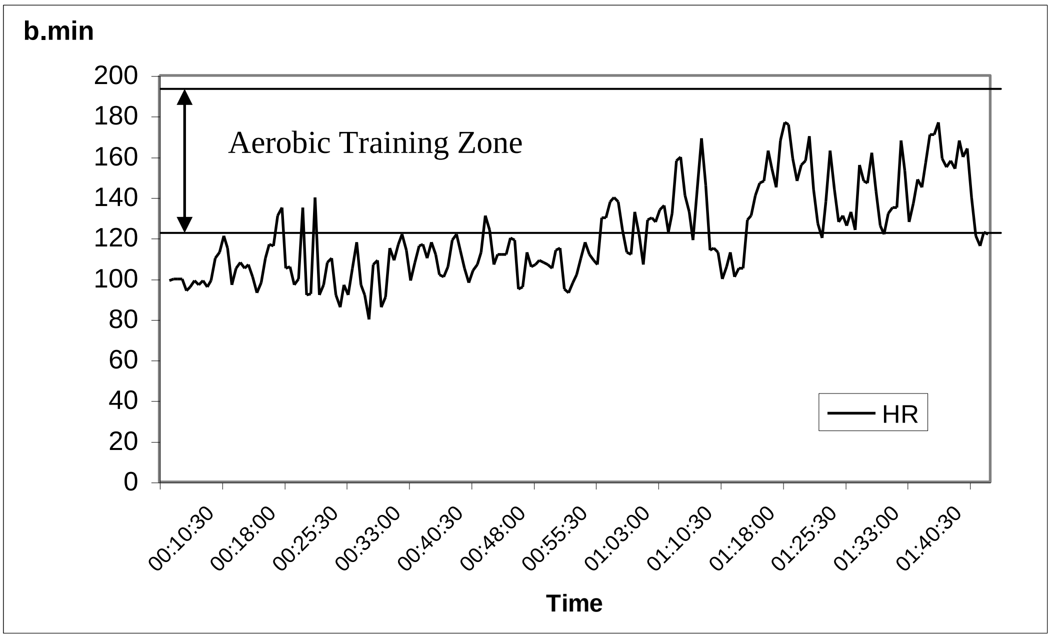
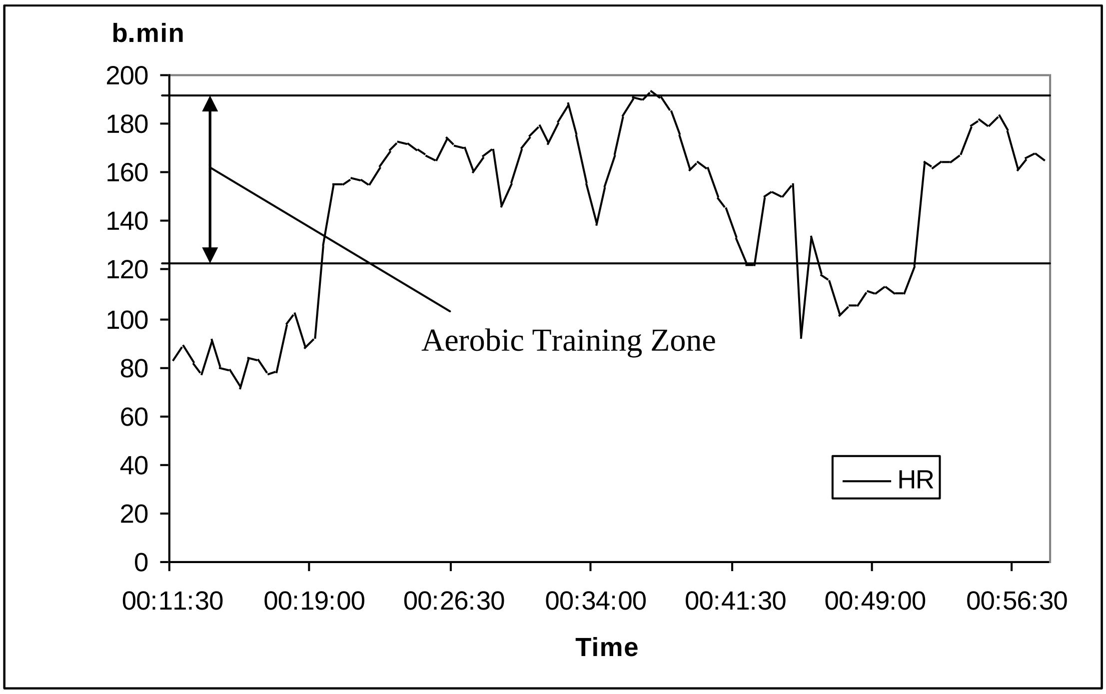


Figure 5 Time spent in Aerobic Training Zone during Performance



Discussion

The main finding of the present study is that class and rehearsal do not prepare the dancer physically for the performance. This finding is based on the significant difference in the oxygen uptake observed between class, rehearsal and performance. Moreover, the time spent by dancers in class at an intensity that is likely to result in a training effect that is too low to adequately prepare them for the demands of performance. Statistical analysis indicates that performance has a greater mean physiological demand than dance class and rehearsal. The data in Table 1 is a mean of a wide range of different performances, the data in Figure 5 shows a demanding performance, whilst at the other end of the scale a dancer maybe only on the stage for 3-minutes throughout a 30 minute performance with a “walk-on” part and very little dancing. The percentage work time (work-to-rest ratio) suggests a greater reliance on the aerobic and anaerobic glycolytic systems than seen during dance class. Recent research has noted an improvement in aerobic fitness during the performance period, though not during similar periods of dance class and rehearsal, which suggests that the intensity and percentage work time during performance is enough to elicit a training effect [11].

The class data collected in the present study is very similar to that reported by previous research [5, 12] with the warm-up sections having an oxygen requirement of between 15-20 $ml.kg.^{-1}min.^{-1}$ and heart rates between 100-120 $b.min^{-1}$. The centre section had lower mean values for both oxygen requirement and heart rate; this is probably due to the whole class being monitored continuously in this study whilst in previous studies only specific dance phases had been monitored.

The mean percentage work time in the present study was significantly longer during the warm-up section than that noted by Dahlstrom *et al* [6], though the centre section had very similar percentages. The work percentages seemed to be dependent on a number of factors. The level of participants (the university dancers spent more time being corrected in technique) and the class size (both university and professional groups had a greater number of participants than the graduate group) were the most obvious variables. Due to the training techniques that are used within dance, only a specific number of dancers can be dancing at any one time during centre work. The movement sequences are often multi-directional and the available space limited, which often limits each run through of a sequence to 3-4 dancers at a time.

The time spent at different heart rate bands shows that for the university and professional dancers the majority of the time was spent at the lower end of their theoretical aerobic training zone during class (60-90% of HR_{max}) whilst the graduate group spent a greater proportion of their time within this zone. This is partly due to the graduate group being potentially less aerobically fit (their mean HR during class is significantly greater than the other two groups whilst their mean $\dot{V}O_2$ is not). The use of heart rates to indicate time spent within training zones for intermittent work is open to question as during recovery periods the heart rate often remains high to compensate for a reduced stroke volume, thereby maintaining cardiac output (the reduced stroke volume is due to a diminished venous return). The use of training impulses is a more accurate way of determining work done [13]. Researchers have noted little or no adaptation of the hearts within dancers, which confirms that the lack of time spent within the aerobic training is not enough to place a stress on the aerobic system [14, 15]. .

As the data indicates there is a significant difference between class and performance in mean oxygen demand, heart rate and heart rate peak frequency, and percentage work time. The centre section of class most closely resembles the physiological cost of performance, though there is a significant difference in the number of heart rate peaks between class and performance, there is no significant difference in the number of peaks >180 $b.min^{-1}$.

Rimmer *et al* [2] monitored ballet rehearsals and suggested that the dancers elicited an aerobic training effect from them due to their interval training nature. They noted that approximately 56% of the rehearsal time was spent within the aerobic training zone.

The mean data from the present study suggests that this is not always the case. The rehearsal period is often a lengthy and complex period where the emphasis is on learning sequences rather than physiological preparation for performance. The intensity of the rehearsal period only increases to that suggested by Rimmer *et al* after the sequences have been learnt and the artistic director is running through the pieces at performance pace. The later usually only happens very close to performance with not enough time to elicit a significant training effect that would benefit the dancer. The lack of physical preparation has been commented on by a dancer who noted, ".. that it often took two weeks of performing before I felt fit enough to give the performance my all" [16].

Practical Applications

The intervention strategy needs to take the form of a periodised training year, though the performance demands and working contracts of dancers make this difficult though not impossible to implement. Krasnow and Chatfield [3] noted that class is probably not the best environment to implement the intervention due to its emphasis on technique. Research needs to be carried out to determine whether class in its present format needs to be carried out daily to prevent loss of technique or can a number of classes a week be substituted for a session with more emphasis on developing specific physiological parameters.

Conclusion

From the data gathered in this study, it can be suggested that class, and for that matter, rehearsal, does not prepare the dancer physically for performance. As Krasnow and Chatfield [3] suggested class can not train the body for everything and should probably concentrate on technique. The dancer will need to undertake supplemental training to prepare themselves for the demands of performance [17]. The data collected in the present study suggests that dance performance is an intermittent form of exercise. Due to its highly complex multi-directional movement requirements, dance can possibly be classified as high intensity intermittent exercise, even though the physiological parameters do not resemble that seen within the sports world. The frequency of technique class to "body-conditioning" will depend on the stage of the dancers career (beginners will require more technique classes than professionals) and the proximity of performance.

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