Highland Dance:
Heart-Rate and Blood Lactate Differences Between Competition and Class

Yvonne Baillie, Matt Wyon, and Andrew Head

**Purpose:** This study looked at the physiological effects of performance in Highland-dance competition to consider whether the traditional methods used during class and rehearsal provide an appropriate training stimulus toward this performance. **Methods:** Nine championship standard, female Highland dancers (age 14.2 ± 1.47 years) had their heart rate and blood lactate concentrations measured before and after 3 dances during a championship competition. Heart rate was also measured during the same 3 dances in rehearsal and during class. **Results:** Repeated-measures analysis of variance showed significant differences in predance lactate concentrations between the first dance (Highland Fling, 1.4 ± 0.3 mM/L), the second dance (Sword dance, 2.3 ± 0.8 mM/L), and the third dance (Sean Truibhas, 3.5 ± 1.8 mM/L; $F_{2,16} = 11.72, P < .01$. This, coupled with a significant rise in lactate concentration during the dances ($F_{1,8} = 76.75, P < .001$), resulted in a final postdance lactate concentration of 7.3 ± 2.96 mM/L. Heart-rate data during competition, rehearsal, and class (195.0 ± 6.5, 172.6 ± 5.4, and 151.9 ± 7.4 beats/min, respectively) showed significant differences between all 3 ($F_{2,16} = 107.1, P < .001$); these are comparable to research on other dance forms. **Conclusions:** Given the disparity between the anaerobic predominance of competition and the aerobic predominance during class, it is suggested that the class does not provide an appropriate training stimulus as preparation for competitive performance in Highland dance.

**Key Words:** aerobic, anaerobic, training, performance

Highland dance is a highly competitive sport not only in Scotland but worldwide, including in Canada, the United States, and Australia. The anatomical demands of this technique include extensive lateral rotation at the hip to maintain the required turned-out foot positions and plantar flexion to aid force production and height in the jumps but also to fulfill the aesthetic expectations of this traditional style of dance. Physiologically, the technique requires both isometrically held positions and rapid bursts of dynamic activity. During competition, dancers, who are usually girls or young women between the ages of 12 and 20 years, execute up to 10 dances each of between 2 and 3 minutes, all within a few hours. As with all sporting events, it...
is essential that training be correctly designed to transfer to optimum performance during competition, in this case to delay skill-sapping fatigue in the latter stages of the event. Traditional activity, however, tends to favor traditional practices during training, in this case, during dance class. Even in contemporary dance, a mismatch between the physical intensity of the class and that of performance has been demonstrated. This might be because, despite the much more varied range of techniques and movement patterns it encompasses, the practices of this more modern form of dance are founded on the traditional classical or ballet system of training.

Physiological profiling of dancers is not new; Cohen et al² and Mostardi et al³ used treadmill-running protocols to measure maximal aerobic power in ballet dancers, whereas Rimmer et al⁴ used a walking profile, but again, on a treadmill. Clarkson et al⁵ investigated maximal oxygen uptake in adolescent female ballet dancers, again using a treadmill protocol. All found similar oxygen consumptions of 40 to 50 mL · kg⁻¹ · min⁻¹, that is, greater than for nonathletic populations but much lower than those of endurance athletes. Analysis of actual oxygen consumption during performance, however, indicates that these maximal values are rarely achieved because the bursts of activity intense enough to elicit such levels are generally too short to actually do so. For female contemporary dancers, for example, mean oxygen consumption during performance has been reported as being as low as 23.34 ± 3.83 mL · kg⁻¹ · min⁻¹. Similarly, although peak heart rates during rehearsal for a ballet performance reached >85% of maximal heart rate (HR_max) for female dancers (n = 8), it was only for a total of 1.7 ± 4.2 minutes out of a session lasting 80 minutes, with each bout lasting just 1 to 6 minutes; the authors described the dancers’ activity as being “interval” in nature. It would seem that a high maximal oxygen uptake is only part of the story concerning what is, essentially, an anaerobic activity consisting of bursts of high-intensity, intermittent activity and involving many changes of direction, interspersed with relatively slower recovery periods. In Highland-dance competition this recovery takes place off stage. Aerobic power is needed for this recovery, but other adaptations to bouts of exercise for which a major energy source is anaerobic glycolysis need to be brought about through suitable training, that is, during class.

Schantz and Astrand⁶ considered the relative intensity of class and performance for ballet dancers. They found that the average oxygen uptake during class was only half that during performance and that blood lactate levels averaged 3 mM/L during class and 10 mM/L during a choreographed piece. Data from Rimmer et al⁷ also showed that although female ballet dancers’ heart rates were elevated above 70% HR_max for almost 40% of a 90-minute class (n = 4), they never achieved the bursts of >85% HR_max found in rehearsal. Wyon et al⁷ have also reported similar discrepancies between class, rehearsal, and performance in both intensity and duration of physical exertion for student and professional contemporary dancers. It is the intent of this article to consider the physiological expectations of competition in Highland dance and to compare them with those of both class and of rehearsal.

Methods

The participants were female (n = 9) championship competitors, age 14.2 ± 1.47 years, height 162.8 ± 8.99 cm, and mass 50.0 ± 8.13 kg. Informed-consent forms were completed by the dancers’ parents or guardians, and all completed a health-history questionnaire before being allowed to participate in the study. Heart
rate was monitored using Polar (Finland) telemetric heart-rate monitors, set to a 5-second averaging period, during a championship competition in which 3 specific dances were performed by each participant (Highland Fling, Sword dance, and Sean Truibhas) with recovery periods averaging 50 minutes, recovery being evaluated as “passive: during rehearsal for the competition in which the same 3 dances were performed, again with 50 minutes recovery, and during a 77-minute class. A video of the class was used to obtain a breakdown of its components: a dance-specific warm-up of 14 minutes, technique for a total of 29 minutes, dance-specific practice for 9 minutes, and a total of 25 minutes of rest periods. Fingertip blood samples were also taken before and after each dance during the competition; whole-blood lactate concentration was determined using an Accusport (Boehringer Mannheim) portable lactate analyzer.

Statistical analysis of mean heart-rate data during competition, rehearsal, and class was conducted through repeated-measures ANOVA. A $3 \times 2$ repeated-measures ANOVA was used to analyze blood lactate data from before and after each dance during the competition. Post hoc within-subject “contrasts” were used to further analyze the predance blood lactate data.

### Results

**Lactate**

A $3 \times 2$ repeated-measures ANOVA indicated that both dance order and pre–post measures showed significant differences in blood lactate concentration (see Table 1). For the 3 dances, $F_{2,16} = 9.36, P < .01$, and for the pre–post differences, $F_{1,8} = 76.75, P < .001$. The interaction between dance and pre–post measures was non-significant ($F_{2,16} = 1.14, P > .05$).

Repeated-measures ANOVA of blood lactate concentrations before each of the 3 dances indicated an overall significant difference, $F_{2,16} = 11.72, P < .01$, with post hoc within-subject contrasts showing that each predance lactate concentration was significantly higher than the preceding one.

**Heart Rate**

Repeated-measures ANOVA on the overall average heart rates in Table 2 indicated significant differences ($F_{2,16} = 107.1, P < .001$) between the 3 dance environments, with within-subject contrasts showing significant differences ($P < .001$) between pairs of environments.

### Table 1 Blood Lactate Concentration (Mean ± SD) Before and After Successive Dances During the Competition

<table>
<thead>
<tr>
<th>Blood Lactate (mM/L)</th>
<th>Dance 1: Highland Fling</th>
<th>Dance 2: Sword dance</th>
<th>Dance 3: Sean Truibhas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before</td>
<td>1.4 ± 0.30</td>
<td>2.3 ± 0.79</td>
<td>3.5 ± 1.84</td>
</tr>
<tr>
<td>After</td>
<td>4.5 ± 1.86</td>
<td>6.9 ± 2.96</td>
<td>7.3 ± 2.96</td>
</tr>
</tbody>
</table>

*a Predance 1 – 2, $F_{1,8} = 12.29, P < .01$; predance 2 – 3, $F_{1,8} = 7.44, P < .05$.\*
Highland dance is unusual, in comparison with classical or contemporary dance, in that its performance takes place under, literally, competition conditions. Every 1 of a series of separate dances is judged on a mixture of timing (with the music); technique, in which elevation or spring plays a major role; and deportment, in which the apparently effortless aesthetics of the piece are displayed. It is consequently important for the dancers to be fully recovered between dance pieces if a progressive deterioration in 1 or more of these 3 factors is not to occur. The blood lactate concentrations measured in this study, taken under genuine competition conditions, show that this progression does, in fact, occur. Statistically significant rises in blood lactate concentrations ($P < .001$) were elicited by the dances that, when taken in conjunction with a steadily rising baseline blood lactate concentration, reached an average of $7.3 \pm 2.96$ mM/L after the third dance, evidence of a marked anaerobic contribution. It should also be remembered that the anaerobic glycolysis mechanism is relatively underdeveloped in adolescents, resulting in lower blood lactate levels than one would find with equivalent exercise intensities in adults. It is the rising baseline, however, that is most important with regard to competitive readiness. Each successive baseline measure was significantly higher than for the preceding dance ($P < .01$), rising to a mean value of $3.5 \pm 1.84$ mM/L just before the third dance, clearly showing that the intervening period and/or activity was not sufficient for full recovery.

The 50-minute recovery period between dances in this particular competition is longer than often experienced at Highland-dance championships and certainly longer than provided at local competitions where dancers are often of lower training status and ability. During recovery from high-intensity exercise the oxygen deficit that has built up must be repaid. A rapid decrease in oxygen consumption after termination of exercise is followed by a more gradual decrease in oxygen uptake in an attempt to return the body to its normal state. Previous research on recovery from strenuous activity has suggested that lactic acid levels can return to resting levels within an hour, although differences might be found in adolescents. Furthermore, the recommended active-recovery exercise intensity to enhance lactate clearance of 50% to 60% of maximal oxygen uptake was not completed by the Highland dancers in this study. If blood lactate accumulation continues toward the end of competition when up to 10 dances might be performed, extremely high lactate concentrations could occur.

### Table 2 Mean Heart Rates (± SD) During Each of the 3 Dances in Both Rehearsal and in Competition and Class

<table>
<thead>
<tr>
<th>Heart Rate (beats/min)</th>
<th>Dance 1: Highland Fling</th>
<th>Dance 2: Sword dance</th>
<th>Dance 3: Sean Truibhas</th>
<th>Overall average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competition</td>
<td>194.2 ± 10.0</td>
<td>196.3 ± 6.3</td>
<td>194.6 ± 6.3</td>
<td>195.0 ± 6.5</td>
</tr>
<tr>
<td>Rehearsal</td>
<td>165.6 ± 6.1</td>
<td>176.9 ± 8.1</td>
<td>174.0 ± 6.0</td>
<td>172.6 ± 5.4</td>
</tr>
<tr>
<td>Class</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>151.9 ± 7.4</td>
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</table>

### Discussion

Highland dance is unusual, in comparison with classical or contemporary dance, in that its performance takes place under, literally, competition conditions. Every 1 of a series of separate dances is judged on a mixture of timing (with the music); technique, in which elevation or spring plays a major role; and deportment, in which the apparently effortless aesthetics of the piece are displayed. It is consequently important for the dancers to be fully recovered between dance pieces if a progressive deterioration in 1 or more of these 3 factors is not to occur. The blood lactate concentrations measured in this study, taken under genuine competition conditions, show that this progression does, in fact, occur. Statistically significant rises in blood lactate concentrations ($P < .001$) were elicited by the dances that, when taken in conjunction with a steadily rising baseline blood lactate concentration, reached an average of $7.3 \pm 2.96$ mM/L after the third dance, evidence of a marked anaerobic contribution. It should also be remembered that the anaerobic glycolysis mechanism is relatively underdeveloped in adolescents, resulting in lower blood lactate levels than one would find with equivalent exercise intensities in adults. It is the rising baseline, however, that is most important with regard to competitive readiness. Each successive baseline measure was significantly higher than for the preceding dance ($P < .01$), rising to a mean value of $3.5 \pm 1.84$ mM/L just before the third dance, clearly showing that the intervening period and/or activity was not sufficient for full recovery.

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levels are likely to be reflected in deficits of balance and coordination, resulting in performance deterioration and a potential increased risk of injury.

In keeping with previous research, the data presented here suggest a lower overall exercise intensity during class than in performance, although it must be noted that class data include periods that could be classified as recovery time. Significantly lower mean heart rates for Highland dancers were recorded at class than at rehearsal (P < .001) and competition (P < .001). A mean heart rate of 152 beats/min, 2 or 3 times a week, indicates the primary use of aerobic metabolism for this group of subjects and therefore an aerobic-training effect. During competition, however, mean heart rates were near maximal (195.0 ± 6.5 beats/min), which, with the high blood lactate levels cited previously, indicates a much larger emphasis on anaerobic energy provision.

Another potential source of heart-rate variation between the class, rehearsal, and competition conditions is that of psychological arousal. Precompetition anxiety, the negative perception of such arousal, has been associated with physiological phenomena involving changes in circulating levels of testosterone, cortisol, and the sympathoadrenal catecholamines. These variously affect nutrient uptake, immune function, blood redistribution, and other cardiopulmonary parameters. Relatively increased levels of cortisol during the 24 hours leading up to competition are thought to mediate the release of the catecholamines, particularly adrenaline, resulting in increases in precompetition heart rate. Female athletes, however, seem to have a less predictable response, with lower reactivity being reported for adrenaline and noradrenaline for the 2 hours preceding competition. The relative elevation of precompetition heart rates in comparison with those elicited by the exercise per se needs, however, to be considered. Although higher heart rates during competition than in the practice environment have been found both at rest and during activity for sports eliciting relatively low heart rates, it is likely that, at the near-maximal heart-rate levels found for the female Highland dancers in this study, the physiological drive to increase cardiac output would supersede the influence of psychological arousal.

These heart-rate levels are slightly higher but commensurate with those found in previous research: Cohen et al recorded values of 137 ± 17 beats/min at class and 184 beats/min during performance in ballet dancers, and Dahlstrom et al found mean heart rates of around 140 beats/min during jazz, ballet, modern, and character dance classes. Furthermore, the difference in the heart-rate–oxygen-consumption relationship for treadmill running and that occurring during the dance class, where a lower oxygen uptake for a given heart rate was demonstrated, would indicate that aerobic stress during the dance class was minimal, with the authors stating that it would be insufficient to act as an aerobic-training stimulus.

Conclusions

The data presented here clearly show that recovery time during competition is insufficient to allow blood lactate concentration to return to resting levels; we suggest that the increasing lactate levels will cause deterioration of performance and increase the likelihood of injury as one progresses through the competition. It has also been shown that current Highland-dance training and rehearsal sessions are not completed at intensities resembling those in competition. Modification of
Highland-dance training to match the needs of competition might enhance competitive performance and reduce injury risk. Alternatively, governing bodies might be advised to either allow increased recovery time between dances or to decrease the number of dances performed in competition in any 1 day.

References