

Cardiorespiratory Profile and Performance Demands of Elite Hip-Hop Dancers

Breaking and New Style

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AIMS: Dancers need to constantly maintain and develop their physiological capabilities to support their performances. Previously these physiological demands have been investigated only in traditional dance styles such as ballet and modern. The aim of this study was to examine the physiological demands of two types of hip-hop: new style and break dance.

METHODS: Nine female new style dancers (age 20±6 yrs, height 163.5±1.4 cm, mass 55.8±22 kg) and 9 male break dancers (age 23±4.2 yrs, height 178.2±5.7 cm, mass 62.1±7.7 kg) volunteered for the study. Each subject completed a maximal graded treadmill test and a dance performance routine, either new style (approx 1:45–2:30 min) or breaking (2 min). Breathe-by-breathe gas analysis and heart rate (HR) were collected by a portable gas analyser, and blood lactate (BLa) was measured at the end of the treadmill test and each routine.

RESULTS: The male breaker dancers had significantly higher VO_2 peak than other equivalent dancers in other genres, whilst the female new style dancers were similar to that previously reported for female dancers. Performance data showed significant differences between the two styles for VO_2 , HR, and BLa ($p < 0.001$) and for VO_2 and HR relative to individual maximal treadmill data ($p < 0.05$).

CONCLUSION: New style is more comparable to other theatrical dance genres, with a lower relative mean VO_2 demand, whilst break dance is shorter in duration, allowing a higher cardiorespiratory demand and generating

significant levels of blood lactate. This difference is also reflected in the dancers' cardiorespiratory profiles. *Med Probl Perform Art* 2018;33(3):198–204.

Dancers have been classified as aesthetic athletes, as although the main performance outcome is artistic, the physiological and psychological demands placed on them are similar to those of sportsmen.^{1,2} Just as the generic term *sport* covers a wide variety of events that can have very diverse physical demands, the same is apparent in dance.³ There has been little scientific research on whether there are physiological, biomechanical, or psychological differences between the dance genres. The majority of studies have examined individual genres usually focusing on the different dance formats (class, rehearsal, or performance)^{4–12} or physical fitness characteristics of its dancers,^{9,13–18} though a few studies have directly compared different genres.^{19–22} Often dancers are trained in the main genres (ballet, contemporary, and jazz) during their vocational training, and being able to isolate the effect of one genre compared to another is only possible in elite adult dancers.

In a number of early studies on dancer's maximal oxygen consumption (VO_2 peak), cycle ergometers were used that led to erroneous data²⁰ due to the unfamiliarity of the activity and difference in peripheral muscle utilisation.²³ In a study of 286 professional dancers, Liiv et al.²¹ noted that the dancesport group had the highest VO_2 peak (males, 60±5.2 mL/kg/min; females, 51±6.0 mL/kg/min) compared to the contemporary (M 57±4.9 mL/kg/min; F 48±6.4 mL/kg/min) and ballet groups (M 50±3.9 mL/kg/min; F 44±5.1 mL/kg/min); these data, for ballet and contemporary dance, are similar to those reported in two systematic reviews.^{14,17} There are very little published data on dancers from other dance genres; Oreb et al.²⁴ reported on female national folk dancers at 37±5.0 mL/kg/min, and Galananti et al.²⁵ and Lavoie and Lébe-Neron²⁶ on female jazz dancers between 49.2±3.6 and 41.5±1.7 mL/kg/min.

In a recent review on the energy demand of dance activity, Beck et al.²⁷ noted methodological limitations of previous research. The studies reported a range of different physiological parameters during either simulated perform-

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ance, dress rehearsal, or real-time performance in dancesport, ballet, contemporary, and highland dance. Only two studies^{28,29} reported peak and mean VO_2 , both in simulated dancesport: peak VO_2 was reported as 50.5 mL/kg/min in males and 43.8 mL/kg/min in females, equating to 88% and 75% of VO_2 peak, whilst mean VO_2 was in the low 30s for females (F) and low 40s for males (M). The majority of studies reported heart rate (HR), either absolute or relative to maximum; maximum heart rates were reported as 178 bpm for ballet⁸ and 187 bpm for contemporary dance,⁷ whilst mean HR for the whole performance ranged for 160 bpm for ballet (M),⁸ 101 bpm for contemporary⁷ (F), 173 (F) and 169 bpm (M) for ballroom,²⁹ and 177 and 168 bpm for Latin,²⁸ expressed as between 85–88% of HR_{max} . Highland and jazz dance seem to be an exception with mean HR reported at 195 bpm³⁰ and 94% HR_{max} ,²⁵ respectively; this could be due to their shorter performance times, where rest periods are not required or part of the choreography. A few studies described end blood lactate (BLa), with dancesport (ballroom and Latin) and highland dance reporting between 6–8 mmol/L and contemporary dance 2.5 mmol/L.³¹

Hip-hop was created on the streets in the 1970s and has a number of subgenres, including breaking and new style as well as funk, locking, popping, and krumping.³² Breaking is the first hip-hop dance style and was classified as one of the five pillars of hip-hop culture, along with rapping, turntablism, graffiti, and knowledge. Breaking includes four foundational dances: *toprock*, footwork-oriented steps performed while standing up; *downrock*, footwork performed with both hands and feet on the floor; *freezes*, stylish poses done on the hands; and *power moves*, complex and impressive acrobatic moves. Breaking battles/performance is improvised in nature and takes place within a circular-shaped dance space formed by spectators. New style is the commercial version of hip-hop and refers to that seen in rap, R&B, and pop music videos and concerts; the style is often seen as pseudo hip-hop as it did not come from the streets and incorporates a lot of jazz dance. New style performances are often stage based and suppress the improvisation which defined hip-hop dance early in its development; it also meshes different dance styles together, dissolving their structures and identities.³²

Although there are major choreographic differences in breaking and new style, the aim of the present study was to examine whether this translates in differing physiological demands of their performances and aerobic profiles of its dancers, in comparison with previously published data on other dance styles (contemporary dance, ballet, and dancesport).

METHODS

The study utilised a cross-sectional observational design with the breaking and new style dance styles as independent variables and the cardiorespiratory profiles (maximal oxygen consumption, $\text{VO}_{2\text{max}}$; maximal heart rate, HR_{max} ;

and blood lactate, BLa) and performance demands (absolute and relative VO_2 , HR, and BLa) as the dependent variables.

Subjects

The study received institutional ethical approval from the University of Wolverhampton (#120586) prior to subject recruitment. Nine female new style dancers (age 20 ± 6 yrs, height 163.5 ± 1.4 cm, mass 55.8 ± 22 kg) and 9 male breakers (age 23 ± 4.2 yrs, height 178.2 ± 5.7 cm, mass 62.1 ± 7.7 kg) volunteered for the study and completed informed consent and Physical Activity Readiness Questionnaire (PAR-Q) forms. All subjects had been free from injury in the previous 3 months.

Procedures

Subjects attended two data collection sessions. The first one was laboratory based and each participant completed a $\text{VO}_{2\text{max}}$ test, underwent anthropometric measurements (age, height, body mass), and familiarised themselves with the portable gas analyser (Metamax 3b Ultra, Cortex, Germany) during dance movement. During the second visit, anthropometric measurements were taken again prior to subjects' completing their dance performance/battle in a dance studio.

Subjects arrived at the laboratory after 12 hrs' rest; height was measured to the nearest 0.1 cm using a SECA 217 stadiometer (Seca, Hamburg, Germany), body mass to the nearest 0.1 kg with SECA 761 mechanical scales while wearing minimal clothing, and age as a whole year. A heart rate monitor (HRM, Polar, Oulu, Finland) was fitted prior to a 10-minute warm-up on a treadmill. The warm-up was used to calculate the speed of the first stage with a target HR of 120 bpm. After the indirect calorimetry equipment (3b Ultra) was calibrated and the subjects fitted with the appropriate mask, 2 min of resting data were collected while the subject stood on the treadmill. The continuous test started at approx. 6–8 km/hr as determined by the warm-up HR. At the end of each 1-min stage, the speed was increased by 1 km/hr until the termination criteria were met or the subject stopped the test by stepping off the treadmill. Termination criteria were: respiratory exchange ratio (RER) 1.15, $\text{HR} \pm 5$ bpm of estimated HR_{max} ($220 - \text{age}$), no increase in VO_2 with an increase in treadmill speed, and rate of perceived exertion (RPE) >19 .³³ A capillary blood sample from the earlobe was taken 2 min post-termination and analysed for BLa using a Lactate Pro-II (Arkray, Kyoto, Japan).

During the familiarisation session, subjects wore the portable calorimetry equipment and HR monitor and experimented with different dance moves. This was especially important for the break dancers because the equipment is situated on their chest and it affects their centre of mass and upper body mobility, thereby either preventing certain moves or requiring moves to be adapted.

On a subsequent day, not more than 2-days post treadmill test, subjects returned to take part in simulated dance performance in a dance studio. Anthropometric data were collected from all subjects again. The new style dancers performed two choreographed dance routines each that the dancers had used during a recent national competition (2 wks prior to the test). The break dancers took part in a simulated “battle,” which was a 2-min improvised routine followed by a response routine from another breaker before the participant responded with another improvised routine. The routines included downrock, power moves, and freezes, with the exception of moves that required chest-floor contact. After a self-administered warm-up, subjects were fitted with a HR monitor and the portable indirect calorimetry equipment. One minute of resting data were collected prior to commencement of dancing. On completion of performance simulation, a capillary blood sample from the earlobe was taken 2 min post-termination and analysed for BLA using a Lactate Pro-II.

Data Analysis

Treadmill test expired gas data were reviewed for single-breathe anomalies (single data points 20% greater than the stage mean) and were removed prior to a 5-breathe smoothing. VO_{2max} was considered to be achieved when there was no increase in VO_2 or HR with workload, the RER was >1.15 , and RPE >19 .³³ If this was not achieved, peak VO_2 was recorded. Expired gas data were analysed using Wasserman methodology to calculate the anaerobic threshold.³³ The ventilatory curve method uses the point at which there is a non-linear increase in ventilation within the plot V_e (L/min) vs time, and the ventilatory equivalents method uses the point at which V_e/VO_2 increases disproportionately while V_e/VCO_2 (plotted against time) stays the same or increases slightly. The anaerobic threshold (%AT) was recorded as a percentage of VO_2 peak.

Simulated dance performance data for single-breathe anomalies (single data points 20% greater than previous and subsequent 5 breathes) were removed prior to a 5-breathe smoothing. Each subject's performance data were further calculated as a percentage of their $VO_{2max/peak}$ and HR_{peak} .

Statistical Analysis

Data were analysed for descriptive statistics, equality of variance, and inter- and intra-group differences using SPSS v20 (IBM-SPSS, Armonk, NY, USA). Descriptive data (mean \pm SD) were calculated for the treadmill cardiorespiratory data for new style and break dancers. Dance performance data were calculated as maximum and mean absolute and relative (% of max) values. Differences within the styles for the dance simulation were examined using a 2×8 -factor ANOVA. The independent variables were routine/set (1 vs 2) and the dependent variables were mean VO_2 and HR, VO_{2max} and HR, and the same variables expressed as a percentage of maximum treadmill data (%max).

TABLE 1. Treadmill VO_2 Peak Descriptive Data for Break and New Style Dancers

	Break Dancers (8 males)	New Style Dancers (9 females)
VO_2 peak (mL/kg/min)	64.8 \pm 2.95	45.9 \pm 5.39
HR_{max} (bpm)	196 \pm 7.81	187 \pm 17.04
BLA (mmol/L)	7.8 \pm 1.76	8.2 \pm 2.52

Data given as mean \pm SD.

One sample *t*-tests were performed to compare previously published dance performance data with the current data; the current break dance data was compared to previously published male dancer data and new style data compared to female dancer data. The alpha level for significance was calculated as $p \leq 0.004$ for break dance and $p \leq 0.007$ for new style to reduce the chance of type I error in recognition of the multiple statistical tests carried out (break dance 12, new style 7).

RESULTS

Two of the 17 subjects achieved 3 of the 4 termination criteria for maximal O_2 uptake during the treadmill test, and therefore VO_2 peak is reported for the remaining subjects. Table 1 provides descriptive data on the two groups cardiorespiratory profiles.

Dance Simulation

There were no reported differences in the dependent variables between the routines/sets within the two styles. Although the physiological data from the break dance sets data were higher than new style data (Table 2, Figs. 1–3), no statistical comparison was made due to the gender differences within this study's population.

Statistical comparison with other dance genres' performance data indicated that although breakdance had a greater peak and mean VO_2 than dancesport (peak 64.8 vs 50.5 ml/kg/min²⁹; mean 48.1 vs 42.8 ml/kg/min²⁸), it was not statistically different; but mean VO_2 was significantly greater than contemporary dance (48.1 vs 24.8 ml/kg/min, $p < 0.001$).⁷ There were no significant differences in peak VO_2 between new style and dancesport (58.6 vs 43.8 ml/kg/min),²⁹ but dancesport had a significantly higher mean VO_2 (27.8 vs 36.1 ml/kg/min, $p < 0.001$).²⁸

Break dance peak HR data were significantly greater than ballet data (191 vs 178 bpm, $p < 0.001$)⁸ but not compared to contemporary dance (191 vs 187 bpm)⁷; and break dance mean HR was significantly greater than ballet,⁸ contemporary,⁷ and dancesport²⁸ ($p < 0.001$). There were no data from other genres to compare peak HR with new style, but mean HR data were significantly lower than highland dance (127 vs 195 bpm, $p < 0.001$)³⁰ and no different than contemporary dance (132 bpm).⁷ End BLA levels were significantly lower than dancesport (8.7 ml/kg/min, $p < 0.001$)²⁹ but higher than contemporary dance (2.45 ml/kg/min)³¹ for both break dance and new style

TABLE 2. Absolute and Relative Physiological Descriptive Data for Simulated Break and New Style Dance Performances

	Break Dancers (8 males)		New Style Dancers (9 females)	
	Set 1	Set 2	Routine 1	Routine 2
Absolute Data				
Peak VO ₂ (mL/kg/min)	64.8 ± 15.43	60.0 ± 17.09	58.6 ± 19.48	57.0 ± 12.79
Peak HR (bpm)	191 ± 8.71	189 ± 6.23	169 ± 43.34	188 ± 16.22
Mean VO ₂ (mL/kg/min)	48.1 ± 12.29	44.3 ± 13.23	27.8 ± 8.33	25.2 ± 6.91
Mean HR (bpm)	178 ± 8.26	177 ± 6.23	127 ± 41.46	157 ± 12.17
End BLa (mmol/L)	5.7 ± 1.35	5.9 ± 1.14	3.6 ± 1.04	3.4 ± 1.37
Relative Data				
Peak VO ₂ (%)	99.6 ± 22.89	92.1 ± 25.21	91.4 ± 21.76	93.6 ± 17.45
Peak HR (%)	97.6 ± 4.01	96.9 ± 4.19	91.3 ± 26.01	99.2 ± 6.38
Mean VO ₂ (%)	73.6 ± 17.03	68.7 ± 21.94	60.2 ± 15.29	55.1 ± 9.82
Mean HR (%)	91.1 ± 5.28	90.6 ± 4.92	67.9 ± 20.98	83.2 ± 5.32

Data given as mean ± SD.

($p < 0.001$) (Table 2). Break dance had similar end BLa to highland dance (6.2 mmol/L),³⁰ but new style was significantly lower ($p < 0.001$).

DISCUSSION

To the authors' knowledge this is the first study examining the physiological demand of two substyles of hip-hop dance. Previous studies have mainly focused on theatrical dance genres, ballet, contemporary, and jazz, though recently dancesport has become a focus. The advent of televised dance competitions (*Dancing with the Stars*, *So You Think You Can Dance*) and YouTube have popularised other dance genres, especially "underground" dance forms such as hip-hop, into the mainstream. These genres have a different aesthetic from theatrical dance and are shorter in duration and often more athletic in their movement.

The peak VO₂ data from the treadmill test in this study was at the upper limits or greater than that reported by dancers in other genres. Previous studies have reported

male dancers ranging between 50–57 mL/kg/min and female 40–47 mL/kg/min for ballet and contemporary dance,^{18,23} though higher scores have been published for dancesport competitors (males 60 mL/kg/min; females 52 mL/kg/min).²¹ Similar to other dance genres, hip-hop dancers do not do a lot of additional supplemental training alongside their dance training. The training of the two different subgenres examined in this study are very different; new style is similar to theatrical dance genres in that training is led by a teacher within a studio setting with a more codified movement system due to its foundations in jazz dance and performance being a rehearsed dance sequence. Breaking is less hierarchical, with peer-to-peer teaching and self-exploration of new tricks and performance having improvisation as its core. With this in mind, the authors have assumed a strong link between the demands of the dance genre and the cardiorespiratory fitness levels of its practitioners.

Compared with other dance genres, new style dance performances and breaking battles are short in duration,

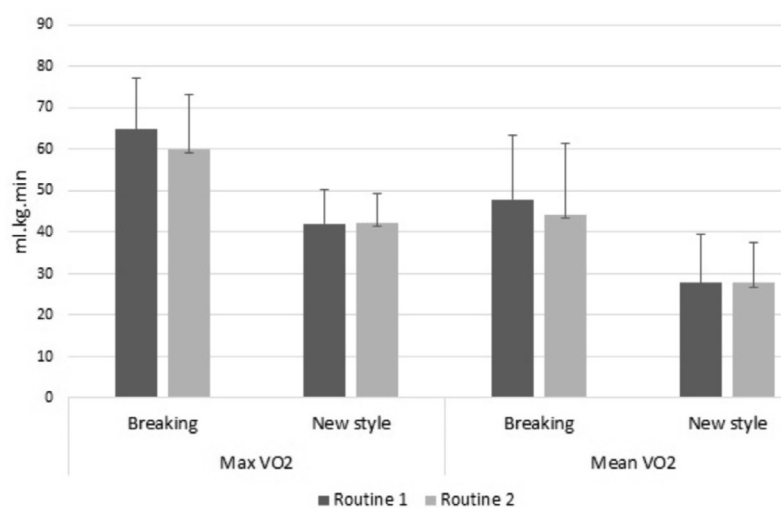


FIGURE 1. Peak and mean physiological descriptive data (mean ± SD) for simulated break and new style dance performances.

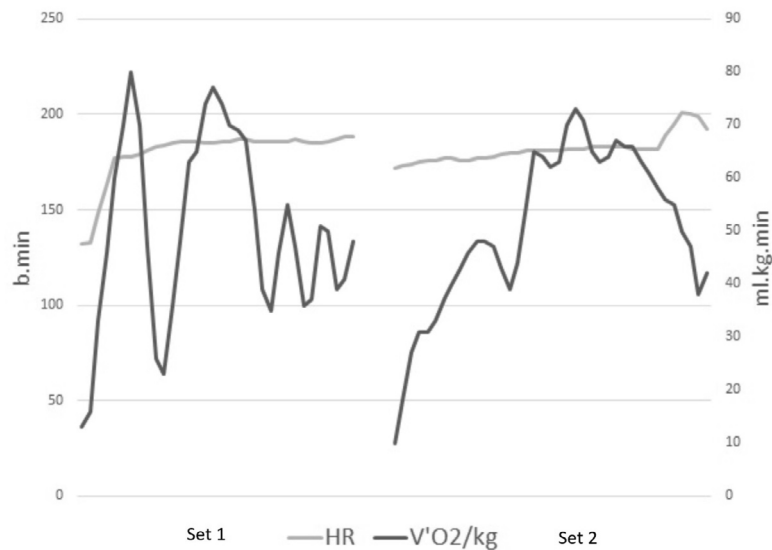


FIGURE 2. Example of cardiorespiratory and HR data from two break dance rounds.

lasting between 2–6 min compared with a 2-hr ballet or 20-min contemporary performance. Although dancers in these performances are not performing for the total duration (62–69% time spent dancing²²), the accumulative dance time is much greater than hip-hop event when breaking battles consist of a number of rounds. There are limited cardiorespiratory data on actual dance performance,²⁷ with most reported data being collected during dance performance simulation as is the case in the present study. New style dance data has a closer proximity to theatrical dance than break dance, possibly due to its underpinning in jazz dance, another theatrical genre, and mean performance HR was similar to contemporary.⁷ The higher mean HR and VO_2 reported for dancesport and highland dance could be because their sequences are shorter than new style, allowing a higher choreographic

intensity, though there was no difference in peak data. This is reflected in end BLa with dancesport and highland dance both reporting greater values.

Break dance rounds are similar in duration to dancesport sequences, and the mean VO_2 data in the present study were similar to that reported in dancesport, though peak VO_2 was higher for break dance and potentially relates to power moves seen in it. The mean HR for break dance was greater than dancesport, again probably due to the power moves. Power moves incorporate dynamic movement with high intensity isometric holds, and these type of moves increase HR disproportionately to VO_2 compared to dynamic movement alone (dancesport).³⁴ The end BLa for break dance was lower than dancesport. Although the present study did not calculate anaerobic threshold in its subjects, the mean VO_2 for break dance rounds were

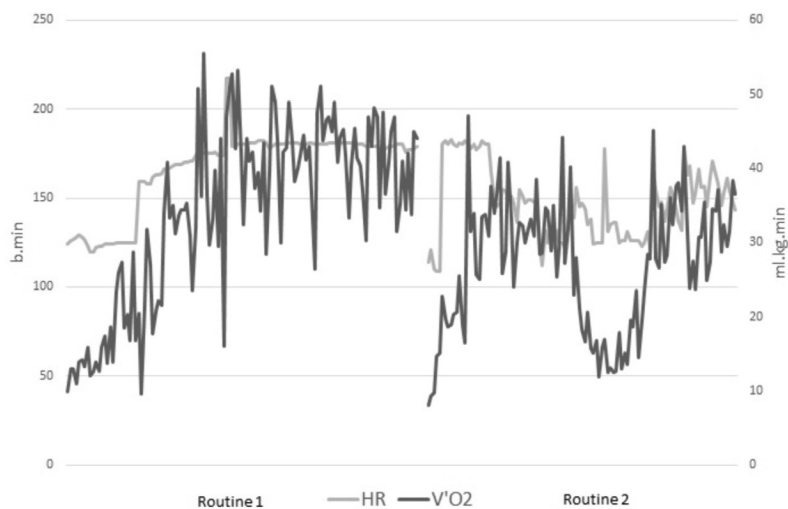


FIGURE 3. Example of cardiorespiratory and HR data from two new style routines. < hi-res, color?>

between 74–69% of their peak VO_2 , potentially below this threshold, but combined with the power moves, it still demonstrates it is a high intensity dance form.

Practical Applications

Practitioners of both subgenres of hip-hop dance seem to have a better developed cardiorespiratory system than their counterparts in other dance genres. Supplemental physical fitness training does not seem to be an inherent part of either subgenre, and therefore the dancers' profiles are potentially a result of their dance training. This could explain why new style dancers had significantly lower VO_2 peak than breakers, as their training has its origins within jazz dance that has a codified technique. Research in other dance genres with codified techniques has indicated that technique class does not stress cardiorespiratory system.^{5,6} We would recommend that supplemental physical fitness training be incorporated into their regimens as a time-efficient method to prepare their bodies for the demands of performance, rather than try and integrate fitness training and technique development into one class.³⁵ Previous research in other genres^{36,37} has shown that supplemental training improves dance performance, but this link has not been examined with hip-hop.

The current study is an initial examination of these two dance genres but is limited by a small number of subjects from a single country and convenience sample. The improvised nature of break dance rounds, the constant evolving choreography of new style dance, and regional variations of each subgenre mean that further research is needed to test the generalisability of the present data in other countries and choreographies.³²

Conclusion

Dance has previously been classified as high-intensity intermittent exercise, and these two subgenres of hip-hop fit into this categorisation. New style is more comparable to other theatrical dance genres with a lower relative mean VO_2 demand, whilst break dance is shorter duration and has a higher cardiorespiratory demand, generating significant levels of blood lactate. Hip-hop dancers have better developed cardiorespiratory systems than other dance genres, which is possibly linked to the increased physiological intensity of dance performance.

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