Influence of movement quality on heart rate while performing the Dance-Specific Aerobic Fitness Test (DAFT) in Pre-professional contemporary dancers

Tiemens, A., van Rijn, R.M., Wyon, M.A, Redding, E. & Stubbe, J.H.

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ABSTRACT

Objectives: To explore whether movement quality is of influence on heart rate frequency during the dance-specific aerobic fitness test (DAFT). **Methods**: Thirteen contemporary dance students (age 19 ± 1.46 years) participated in the current study. The participants underwent two trials performing the DAFT while wearing a Polar heart rate monitor (Kempele, Finland). During the first trial the dancers were asked to perform the movements as if they were performing on stage, whereas during the second trial standardized verbal instructions were given to reduce the quality of movement, e.g. no need to perform technically correct pliés. The variables measured at each trial were heart rate values for all 5 stages of the DAFT and heart rate recovery (1 and 2 minutes after finishing the DAFT), a movement quality score (MQ) ranging from 0 (excellent movement quality) – 45 (poor movement quality), and a rate of perceived exertion score (RPE) ranging from 6 (no exertion at all) – 20 (maximal exertion). **Results**: There were significant differences in heart rate values between Trial 1 and Trial 2. For all stages and the resting period the heart rate was lower during Trial 2 ($p<0.001$). Also, the RPE score was significantly lower and the MQ score was significantly higher during Trial 2 (both $p<0.001$). **Conclusion**: The results suggest that DAFT performance with lower movement quality elicit lower heart rate frequency and RPE during the DAFT. We recommend that specific instructions are given regarding how the movement sequence of the DAFT should be performed before testing commences. Also, movement quality must be taken into account when interpreting heart rate results from the DAFT in order to distinguish if a dancer has a low heart rate resulting from good aerobic fitness or from poor performance of the movement sequence.

INTRODUCTION

Dance is categorized as a high-intensity intermittent activity, since dance exercises and performances consist of short bouts of exertion followed by a relatively long period of rest (1–3). Despite the relatively high amount of recovery time, the overall intensity of exercises during classes and variations during performance can be quite high. During center- and floorwork and performances oxygen consumption can rise up to 60% and 80% of VO_{2max}, respectively (1,4).

Several studies showed that cardiorespiratory requirements, e.g. heart rate and oxygen consumption, during classes and rehearsals are not sufficient to prepare dancers for the physical demands of performances (5,6). There are often no cardiorespiratory training effects after long periods of dance training alone since the training impulse of classes is too low due to a high amount of recovery time and a low overall heart rate (2,5). Therefore supplemental training is desirable if a dancer needs to improve aerobic fitness in order to meet with the demands of the performance (2,5). Additionally, low levels of aerobic fitness were found to be positively related with higher numbers of injuries (7). A better aerobic fitness results in a faster recovery between two successive exercises and thus in a slower onset of fatigue which is an indirect cause of injury (8,9). Therefore, dancers are required to possess a certain base level of aerobic fitness in order to complete classes, rehearsals and performances without being at risk of sustaining an injury.

Physical screening of contemporary dancers' aerobic capacity at the beginning of a new season can be very helpful to detect which dancers have low levels of aerobic fitness and might therefore be at higher risk of sustaining an injury. Originally, graded cycle ergometer tests were used to determine maximal oxygen uptake amongst dancers (1). However, recently it was found that predicting oxygen consumption in dance from a HR-VO_2 relationship derived during a cycling test was not reliable (10). Lower levels of oxygen uptake were found for similar heart rates during classes when compared with the exercise test. The authors concluded that this was due to the non-steady state characteristics of dance, which cannot be compared with data from a steady state activity such as running or cycling (10). It was found that the Interval Shuttle Run Test (ISRT) was a reliable test for intermittent sports (11). Although dance is described as an intermittent type of exercise (3), the ISRT does not lead to accurate predictions of aerobic capacity because dancers often feel restricted while running due to anatomical characteristics (12).

Given that measuring aerobic fitness in dance with a graded ergometer test or the ISRT is not reliable, a dance-specific aerobic fitness test (DAFT) was developed to determine aerobic fitness in dancers (12,13). The DAFT consists of a contemporary dance sequence of five stages, and at the end of each stage heart rate and oxygen consumption can be measured (12). The developers of the DAFT intended for the test to be used as an easy-to-administer field-based assessment of aerobic fitness whereby HR measurements and oxygen uptake are used to determine fitness levels in contemporary dancers. The authors concluded that the DAFT was a valid test to determine aerobic fitness in contemporary dancers since heart rate frequency and oxygen uptake during stage three reflect that of contemporary dance classes and at end of stage five mirrors that of performances (12). Moreover, there was a high correlation between oxygen uptake and heart rate frequency ($r=0.91$, $p<0.001$). The reliability of the DAFT was assessed by determining the coefficient of variation (CV) between two separate trials. CV was between 1.4 and 6.0% for all stages (12).

Several studies have already used heart rate measurements during the DAFT to determine aerobic fitness in dancers. These studies found an association with injury levels and aesthetic competence (7, 15). Moreover, Angioi et al. (2012) used the DAFT to measure the effect of supplemental training on aerobic fitness and aesthetic competence. The supplemental training resulted in lower heart rate frequency at the end of the DAFT. This coincided with a increase in aesthetic competence (14). However, to date no research of possible confounding factors on the outcome of the DAFT was published. Therefore, this paper aims to study whether differences in movement quality will influence the heart rate frequency during the DAFT. It is hypothesized that there is a correlation between movement quality and heart rate frequency. A low quality of movement during the DAFT will result in an overall lower heart rate than when the dancer executes the DAFT as if it was a performance.

METHODS

Participants

Thirteen contemporary dance students (N=13; 7 males, 6 females; age 19±1.46 years) volunteered to participate in the present study. The participants were either first (N=5, 38,5%) or second year (N=6, 46,2%) full-time students in a bachelor's degree in Dance or first year (N=2, 15,4%) students in a bachelor's degree in Dance in Education at --. All participants were healthy and free of injuries. Prior to testing, the participants completed a Physical Activity Readiness Questionnaire (PAR-Q) to determine whether they would be able to participate in the study and they completed a consent form. Ethical approval was provided by the Medical Ethics Review Committee of the -- (W15_200).

DAFT

The dance-specific aerobic fitness test (DAFT) consists of five stages of 4 minutes in duration, with a total test time of 20 minutes. Every 4 minute continuous stage resembles a contemporary dance sequence comprising of the same movements: lunges, pliés, jumps and circular arm movements. Between every successive stage there is an increase in movement tempo and movement difficulty (16). For a extensive explanation about the movement sequence of every stage see Redding & Wyon (2010).

The outcome measurement of the DAFT is heart rate frequency at the end of every stage. Furthermore, it is advised by the designers of the test to observe movement quality, although no clear guidelines are presented in the test manual (16). The following determinants are proposed to be used: sequencing, coordination, effort levels, travelling distance, pointed feet, consistent arm position, lunge depth (chest to thigh), jump height & overall movement quality.

Procedures

The participants were tested on two separate trials within a period of one month. For the purposes of this current study, a familiarization trial was not needed since all dancers were already familiar with the protocol of the DAFT and had performed the test at least once in the past year. To be sure all dancers remembered the choreography, the dance sequence was repeated before starting the DAFT. At the end of the DAFT, participants were required to sit down for two minutes to rest.

The participants wore a Polar team 2 heart rate monitor (Kempele, Finland) that was connected to the corresponding software on a laptop. The heart rate responses to the test and rest period were recorded and markers were placed to indicate the beginning and end of the five stages and 1 and 2 minutes of rest. The markers were used to determine the mean HR during the last minute of all stages (14) and after the first and second minute of rest.

Next to the subjective measurement of intensity (HR) a subjective measurement was used by asking the participants to grade the rate of perceived exertion (RPE) directly after stage 5 was completed by using the 6-20 Borg-scale (17).

For Trial 1, the original instructions as described in the manual of the DAFT (16) were given to the participants: executing each stage as fully and accurate as possible, starting each stage at relatively the same place in space, and execute the test as if you are performing on stage. For Trial 2, the participants were instructed verbally to perform with a lower quality of movement. A standardized protocol, based on the nine determinants of movement quality, was used to make sure all participants received the same instructions. The instructions were focused on reducing movement amplitude (e.g. smaller pliés, lower jumps and smaller travelling distance). Besides, participants were instructed to be less technically perfect when performing movements such as pliés and sautés.

To determine the quality of movement, the participants were filmed while performing the test on both occasions. The videos were used to assess the movement quality by using the nine movement observations that have been advised in the manual (16). A scientist that was blinded for the experiment scored the movement quality. Every time a participant could not maintain the same technical quality or amplitude of the movement for one of the nine variables throughout a stage a tally mark was given. Adding the tally marks for each participant resulted in a total movement quality (MQ) score for both trials ranging from 0 (excellent movement quality) to 45 (poor movement quality).

Statistical analysis

Data was analyzed using IBM SPSS Statistics Software (ver. 24, IBM-SPSS, Armonk, NY, USA). To determine if the data was normally distributed Skewness and Kurtosis scores were calculated and the Kolmogorov-Smirnov normality test was applied. Paired t-tests were performed to determine statistical differences for HR, MQ and RPE data between the different trials. In order to explore correlations between HR, MQ and RPE, individual differences (Trial 1 vs. Trial 2) were determined for HR at the end of stage 5, MQ and RPE, resulting in a $HR_{difference}$, $MQ_{difference}$, and $RPE_{difference}$ score for each participant. Pearson correlation coefficient was used to explore linear correlations between $HR_{difference}$, $MQ_{difference}$ and $RPE_{difference}$. Statistical significance was set at $p<0.05$ for all analyses.

RESULTS

Heart rate frequency

All participants were able to perform the movements of the DAFT and were able to complete the full test at both trials. Table 1 shows the mean and standard deviation in heart rate per stage as well as RPE and MQ scores for Trial 1 and Trial 2.

For the heart rate frequency during the DAFT a significant mean difference was found between Trial 1 and Trial 2 in all stages and the two minutes of recovery. HR mean differences (MD) between Trial 1 and Trial 2 ranged from 23.39 – 45.08 bpm, see Table 1. HR was significantly higher during Trial 1 than during Trial 2 for all stages and the recovery period.

Movement quality and RPE

Table 1 shows a significant reduction in movement quality between both trials as seen by a higher MQ score for Trial 2 (MD:15.85±4.72) and a significant lower RPE score in Trial 2 compared to Trial 1 (MD:4.62±1.45).

An overview of the determinants scored to generate the MQ scores can be found in Table 2. This table shows the number of observations for all stages and all participants. From Table 2 it can be concluded that the largest difference in movement quality between Trial 1 and Trial 2 was found for the determinant effort level. A significant difference was found for sequencing, effort level, consistent arm position, lunge depth(chest to thigh) and overall movement quality. For the determinants pointed feet and jump height the results were non-significant. Strikingly, the determinant lunge depth (chest to thigh) was scored often during both trials, whereas coordination and travelling distance have not been used in either trial.

No significant correlations were found between $HR_{difference}$ and $MQ_{difference}$ (r=0.394, p=0.183). Neither for the difference in $HR_{difference}$ and $RPE_{difference}$ (r=0.180, p=0.557).

DISCUSSION

The aim of this study was to assess whether movement quality is associated with the heart rate response during the DAFT. For Trial 1 the mean HR at the end of stage 5 was 190 bpm, which is 94.5% of the mean expected HR_{max} (220- mean age). For Trial 2 the participants reached only 71.6% of their expected HR_{max}. Additionally, RPE was significantly lower. This shows that both objective and subjective variables of intensity were lower in Trial 2. Next to a decreased HR and RPE, movement quality was worse in the second trial. The results of the present study suggest that a lower quality of movement coincides with a lower heart rate during all stages of the DAFT and a lower subjective perceived exertion. However, due to the absence of correlations between $HR_{difference}$, $MQ_{difference}$, and $RPE_{difference}$ it remains unclear if the participant with the largest difference in heart rate between Trial 1 and Trial 2 was also the participant with the greatest difference in movement execution.

In order to monitor physical fitness throughout the year comparisons between the HR results of the DAFT at different time points are required. The results of the present study show that the movements need to be performed as standardized as possible to reduce the effect of movement quality on the heart rate frequency. Therefore, the use of clear instructions is necessary. It is suggested that multiple movement quality determinants should be observed during the DAFT (12). These variables were sequencing, coordination, effort levels, travelling distance, pointed feet, consistent arm position, lunge depth (chest to thigh), jump height & overall movement quality. Unfortunately, the authors do not provide further directions for the observations of these movements. As a result, it is up to the interpretation of the observer to determine whether a dancer performs the movements in a standardized way each time they perform the test.

Therefore studies are needed to determine which MQ determinants are the main contributors to the HR differences as found in the present study and if determinants are missing in the current observation guidelines. For example, the observer noted that one participant had a lot of movement in the trunk when doing the pliés during the test, but could not attribute this to one of the determinants. The main determinants that were used most in both sessions were sequencing, pointed feet, consistent arm position, lunge depth and jump height. Also, the largest difference in total number of observation between Trial 1 and Trial 2 was found for the determinants effort level and overall movement quality. Therefore, it is likely that poor performance on these determinants will lead to the reduction of the heart rate frequency during the DAFT. However, no correlation between movement quality and heart rate frequency was found in the present study. The absence of such a correlation can be explained by the fact that every determinant could only be used once during a stage. If a participant made one mistake in the sequencing of the choreography this was scored as one tally mark for sequencing, however if another dancer performed a lunge that was not correct throughout the whole stage this was also scored as one tally mark for lunge depth (chest to thigh). Both contributed equally to the MQ score, although it is to be expected that one mistake in sequencing does not contribute to a lower or higher heart rate, but a constant poor lunge would. Therefore, a clear protocol describing how to measure movement quality and how to take into account the MQ score when interpreting the HR outcome of the DAFT is necessary.

The present findings further suggest that the RPE measurements cannot be used separately from HR measurements to determine the intensity of the test. The RPE score was originally correlated to heart rate, a score of 6 equals a HR of 60 bpm and a score of 20 equals a HR of 200 bpm (17). However, this one-to-one correlation was not found during the present study, since the $HR_{difference}$ between Trial 1 and Trial 2 was not correlated to the $RPE_{difference}$. Therefore, it is advised to use the RPE next to the HR measurements to gain insight in the dancer's perceived exertion of the test, but not to use as a single measurement of intensity.

This study has several strengths. Firstly, it is the first paper that addresses the influence of movement quality on the heart rate during the DAFT. Secondly, by using the Polar Team 2 system, heart rate frequency was continually recorded throughout the test. Thereby the mean HR over the last minute of every stage could be determined, resulting in a reliable and objective value. Another strength of the study is that it included a homogenous group of young, high level contemporary dancers. However, the study also has some limitations. First, only a small number of participants was included, which might contribute to the lack of correlations between HR, MQ and RPE scores. Second, the two trials were separated by a period of maximum one month. It is questionable if training effects occurred within this period. However, several studies suggested that performing dance training alone is not sufficient to improve aerobic fitness (5,6). Moreover, a study by Angioi et al. (14) showed a decrease in HR of 19 bpm after a 6-week supplemental training intervention, whereas the control groups only improved by 11 bpm. In the present study the difference in HR at the end of the DAFT is 45 bpm. The students in the current study received their regular educational program over the one-month period. Therefore, the difference in heart rate cannot be explained by an improvement in aerobic fitness alone. Another limitation of this study is the lack of randomization of the participants and the two trials. Ideally this study needs to be repeated and participants should be assigned to two groups randomly with one group performing Trial 1 first and Trial 2 second, and a second group performing Trial 2 first and Trial 1 second. Finally, due to the exploratory nature of the study, no adjustment for the multiple comparison issues was made.

CONCLUSION

Our study showed that movement quality influences heart rate during the DAFT. Therefore, it is important to give clear instructions about the movement quality to the participants before the test starts. Furthermore, movement quality should be scored during the test and standardized observation guidelines are required as well as clear instructions how to use the MQ score while interpreting the HR outcome of the DAFT. When using HR as the only outcome measurement of the DAFT it can be concluded that the dancer has a good aerobic fitness, whereas this might also be the result of poor performance of the movement sequence.

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Table 1. HR (bpm) for all stages, MQ scores (range 0-45) and RPE (range 6-20) scores in Trial 1 and Trial 2 (Mean ± SD).

	Trial 1	Trial 2	Mean difference	p-value
HR Stage 1	122 ± 12.85	104 ± 10.66	17.38 ± 9.62	p < 0.001
HR Stage 2	135 ± 14.04	111 ± 12.75	24.23 ± 9.81	p < 0.001
HR Stage 3	165 ± 15.34	124 ± 14.70	41.00 ± 12.52	p < 0.001
HR Stage 4	181 ± 10.07	136 ± 14.61	44.46 ± 12.96	p < 0.001
HR Stage 5	190 ± 7.13	144 ± 14.26	45.08 ± 13.28	p < 0.001
HR Rest 1	140 ± 7.23	104 ± 15.62	36.46 ± 13.14	p < 0.001
HR Rest 2	115 ± 8.10	91 ± 20.24	23.38 ± 17.18	p < 0.001
MQ	3.77 ± 2.89	19.62 ± 3.43	-15.85 ± 4.72	p < 0.001
RPE	14.15 ± 1.63	9.54 ± 1.66	4.62 ± 1.45	p < 0.001

Table 2. Observations for the different determinants of the MQ score for all stages and all participants separated for Trial 1 and Trial 2 (Mean ± SD).

	Trial 1	Trial 2	p-value
Sequencing	1.00 ± 0.707	3.40 ± 0.894	0.009
Coordination	0	0	-
Effort Levels	0	10.80 ± 2.683	0.001
Travelling Distance	0	0	-
Pointed Feet	1.80 ± 2.049	7.40 ± 6.804	0.075
Consistent Arm Position	1.80 ± 1.643	7.80 ± 5.357	0.028
Lunge Depth (Chest to Thigh)	4.00 ± 2.550	8.20 ± 3.834	0.008
Jump Height	1.20 ± 1.789	7.40 ± 6.804	0.072
Overall movement quality	0	5.60 ± 3.130	0.016