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ORIGINAL ARTICLE

Using heart rate monitors to assess energy expenditure in four training types

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ABSTRACT

BACKGROUND: Heart rate (HR) measurements and energy expenditures (EE) are compared for zumba, interval 4x4 min spinning, interval 4x4 min running, and pyramid running (1 min recovery periods followed by activity periods decreasing from 6 min to 1 min).

METHODS: Twenty-six men and women (21.8±2.4 years) completed all four sessions. Zumba lasted 60 min, and the three other sessions lasted 45 min. EE was estimated by heart rate measured by Polar heart rate monitors.

RESULTS: During the 33% longer zumba session the participants used 592±161 kcal, which was 14.2% higher than during 4x4 running ($P=0.003$). The EE in kcal/min was 13.9% lower in zumba compared to 4x4 running ($P<0.001$). For spinning and running %HRmax exceeded 90% in all activity periods ($P<0.01$), and decreased below 78% in all four recovery periods ($P<0.05$). For pyramid running %HRmax exceeded 90% in all seven activity periods ($P<0.01$), and decreased below 86% in all six recovery periods ($P<0.05$).

CONCLUSIONS: First, we consider zumba which has hardly been analyzed. Second, we compare zumba with three forms of intervals; running 4x4, spinning 4x4, and pyramid running. Third, we explicitly analyze the time factor through the sessions. Fourth, we analyze how heart rates decrease during 3 min vs 1 min recovery periods. Fifth, we scrutinize how heart rates increase during short vs long activity periods.

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Key words: Running - Heart rate - Energy metabolism - Dancing - Exercise test - Bicycling.

The literature has provided insight into heart rate (HR) and energy expenditure (EE) for various training forms such as weight lifting, step aerobics, etc.[1-13] Hausken and Tomasgaard [14] showed energy expenditure variations during interval training where multiple training forms (step aerobics, weight lifting, etc.) are joined sequentially into one exercise class. Helgerud, Hoydal [15] considered the effect of four different training methods on maximal oxygen uptake (VO_{2max}) and stroke volume; long slow distance running at 60% of VO_{2max}, lactate threshold running at 80% of VO_{2max}, 15/15 seconds interval training at 87.5% vs 60% of VO_{2max}, and 4x4 min interval training at 87.5% vs 60% of VO_{2max}. Analyzing how different exercise activities affect our HR and EE is important to understand the training effect of specific training programs.

We seek to gain insight into three kinds of interval training compared with one kind of training not involving intervals. Comparing different interval sessions against each other is important to determine differences in energy expenditure. Comparing running against spinning is important since these are common training forms and practitioners need to assess their possibly different impact. Comparing interval training against Zumba with no intervals is important to determine how intervals impact energy expenditure, and to determine the overall energy expenditure in Zumba compared with the other three training types.

The first training type is 4x4 spinning, *i.e.* 4 min spinning ca 90-95% of max heart rate and 3 min spinning ca 70% of max heart rate, four times. The second is 4x4 running with the same structure. The third is pyramid running, *i.e.* running 90-95% of max heart rate during periods decreasing from 6 min to 1 min, interspersed with jogging ca 70% of max heart rate for one min). The fourth is zumba without intervals. Zumba is a Latin dance-inspired fitness program created by dancer and choreographer Alberto "Beto" Perez in Colombia during the 1990s, gaining increasing popularity.[16] Zumba is chosen due to its current popularity and since it has received virtually no scientific scrutiny. As of September 7, 2014, the only available studies in the ISI base are Luettgen, Foster [17] and Sanders and Prouty.[18]

The paper has eight objectives and tests eight hypotheses. First we determine how the heart rates and energy expenditures differ for zumba and the three other sessions. Second, we determine how the total energy expenditures differ for 60 min zumba and 45 min for the three other sessions. Third, we compare heart rates and energy expenditures for 4x4 running and 4x4 spinning. Fourth, we compare heart rates and energy expenditures for pyramid running and 4x4 running. Fifth, we determine how the heart rates decrease during the 3 min recovery periods in 4x4 running and 4x4 spinning. Sixth, we determine how the heart rates decrease during the 1 min recovery periods in pyramid running. Seventh, we compare how the heart rates decrease during the recovery periods in pyramid running and 4x4 running. Eighth, we compare how the heart rates increase during the activity periods in pyramid running and 4x4 running.

We analyze the following eight research hypotheses. The motivation for Hypothesis 1 is the current uncertainty about the impact of the popular zumba training in terms of heart rates and energy expenditures. We test this by letting the same participants train zumba and three other training types.

Hypothesis 1: The mean %HRmax and mean energy expenditures are the same during zumba and 4x4 running.

Whereas Hypothesis 1 focuses on the mean, the motivation for Hypothesis 2 is that zumba lasts 15 minutes longer and the total energy expenditures may possibly larger.

Hypothesis 2: The total energy expenditures are the same during 60 min zumba and 45 min 4x4 running.

The motivation for Hypothesis 3 is the need to compare interval running with interval spinning. It is well known that participants' max heart rates are lower for spinning (cycling) than for running, especially because the upper body is used to a lower extent. For example, Faulkner *et al.*[19] determine 11% lower VO_{2max} for cycling compared with running. We seek to expand upon such insights during interval training. Especially, we seek to determine whether the participants in 4x4 spinning compensate for the lower heart rates and energy expenditures during the intervals with higher heart rates and energy expenditures during the recovery periods.

Hypothesis 3: The mean %HRmax and mean energy expenditures are the same during 4x4 running and 4x4 spinning.

The motivation for Hypothesis 4 is the need to compare pyramid running with interval running. First, in pyramid running the recovery periods are shorter than in interval running, one minute instead of three minutes. Second, in pyramid running the first interval lasts six minutes, the second lasts five minutes, decreasing to one minute for the last interval.

Hypothesis 4: The mean %HRmax and mean energy expenditures are different during pyramid running and 4x4 running.

The motivation for Hypothesis 5, for 4x4 running and 4x4 spinning, is to assess %HRmax and energy expenditures during the 3 min recovery periods, inserted between the 4 min interval periods. First, how quickly do the heart rates and energy expenditures decrease at the onset of each recovery period, and how quickly do the heart rates and energy expenditures increase at the onset of each interval period? Second, to which levels do the heart rates and energy expenditures decrease in the recovery periods and increase in the activity periods? The 78%, 86% and 8.4% numbers in Hypotheses 6-8 were chosen to get succinct results for when the hypotheses are rejected.

Hypothesis 5: During the 3 min recovery periods in 4x4 running and 4x4 spinning the participants are not able to decrease their heart rates from above 90% of HRmax to below 78% of HRmax.

The motivation for Hypothesis 6 is similar to that of Hypothesis 5, but applied to pyramid running where the recovery periods are only 1 min and the activity periods start with 6 min and decrease to 1 min. First, do the heart rates and energy expenditures decrease and increase in the same manner as in the 3 min recovery periods in 4x4 running and 4x4 spinning? Second, do the heart rates and energy expenditures decrease to the same levels in 4x4 running and 4x4 spinning? Third, to which levels do the heart rates and energy expenditures decrease in the recovery periods and increase in the activity periods?

Hypothesis 6: During the 1 min recovery periods in pyramid running the participants are not able to decrease their heart rates from above 90% of HRmax to below 86% of HRmax.

The motivation for Hypothesis 7 is the short recovery periods in pyramid running which suggest that the participants are not able to decrease their %HRmax as much as during the recovery periods in 4x4 running and 4x4 spinning.

Hypothesis 7: During the 1 min recovery periods in pyramid running the participants decrease their %HRmax to a level less than 8.4% above the minimum %HRmax during the 3 min recovery periods in 4x4 running.

The motivation for Hypothesis 8 is that the activity periods in pyramid running last 22 min as opposed to 16 min for 4x4 running, combined with the short recovery periods in pyramid running, which jointly suggest that the participants during pyramid running do not reach the high %HRmax reached during 4x4 running.

Hypothesis 8: During the activity periods in pyramid running the participants increase their %HRmax to a level more than 5% below the maximum %HRmax during the activity periods in 4x4 running.

Materials and methods

Participants

The participants were mainly recruited among university sports students and a total of 34 participants (22 females) were included, while 26 participants (15 females) with a mean age of 21.8±2.4 years completed all exercise sessions. Men's weight and height were 73.4±7.3 kg and 178.6±8.6 cm respectively. Women's weight and height were 57.5±4.0 kg and 164.2±6.9 cm respectively. We assume PAR=7 (Physical Activity Rating, see equation (4)). The study information was explained orally and in writing and the volunteers gave their written informed consent. The study was submitted for Institutional Review Board (IRB) approval by the Norwegian Ethics Committee (http://helseforskning.etikkom.no/xnet/public) which concluded that the study, which is observational of one physiological variable (heart rate), does "not require formal IRB approval according to Norwegian laws and regulations in force." The study was approved by the Norwegian Social Science Data Services AS.

Design

The participants carried out four exercise sessions at SiS Sports Center at the University of Stavanger, Norway: Zumba January 16, 2012 at 18:00-19:00, 4x4 running January 19, 2012 at 15:15-16:00, 4x4 spinning January 23, 2012 at 15:15-16:00, pyramid running January 26, 2012 at 15:15-16:00. For zumba the participants were told to follow the instructor's instructions. For the three other sessions each participant knew its max heart rate, and followed the instructor's instructions through the intervals.

Zumba 60 min: First warmup one song, thereafter zumba, and cooldown one song at the end.

4x4 running 45 min: First 12 min warmup, then 4 min running ca 90-95% of max heart rate and 3 min jogging ca 70% of max heart rate, four times, for a total of 28 min, and finally 5 min cooldown.

4x4 spinning 45 min: Same structure as 4x4 running, replacing running/jogging with spinning.

Pyramid running 45 min: First 12 min warmup, then 6 min running 90-95% of max heart rate and 1 min jogging ca 70% of max heart rate, then 5 min running and 1 min jogging, 4 min running and 1 min jogging, 3 min running and 1 min jogging, 2 min running and 1 min jogging, 1 min running and 1 min jogging, and finally 1 min running and 5 min cooldown.

Measurements

Polar team 2 heart rate belts and RS 100 monitors (Polar Electro Oy, Kempele, Finland) were used to measure the participants' heart rates every 5 seconds. Body weight was measured using a calibrated, digital scale (Seca model 770, Seca GmbH & Co, Hamburg, Germany) while body height was self-reported. The participants measured their maximal HR indoor or outdoor by the following standardized protocol: 20 min with increasing running intensities followed by five min stretching. Then two uphill running intervals (5% incline at treadmill) lasting 3 min. The first interval should be hard, but not to exhaustion. Three minutes active break was followed by a running interval to exhaustion. The session ended by 15 min cooldown running. The highest registered HR was set to maximal HR (HR_{max}). Resting HR was measured by participants in bed at morning (HR_{rest}), while sitting HR was measured during day while sitting still (HR_{sit}).

Statistical analysis

Equations (1)-(5) were used to determine the participants' activity energy expenditure (EE). We compare two methods A and B to strengthen the study. Hiilloskorpi *et al.*'s (20), p. 441) model 2 equation, hereafter referred to as method A, is

$$\begin{aligned} EE &= -1.68 + 10.84 \times gender + \\ &HR\,(0.043 - 0.106 \times gender) - \\ &weight\,(0.105 + 0.101 \times gender) + \\ &\text{age}\,(0.095 - 0.107 \times gender) + \\ &HR \times weight\,(0.00134 + 0.00119 \times gender) - \\ &HR \times \text{age}\,(0.0011 - 0.00110 \times gender) \end{aligned} \qquad (1)$$

Equations (2)-(5) are hereafter referred to as method B. Kinnunen and Nissilä [21] estimated the three data points (HR_{low}, EE_{low}), (HR_{high}, EE_{high}), and (HR_{max}, EE_{max}) defined as

$$\begin{aligned} &HR_{sit} \text{ is measured empirically (or between 65 bpm and 70 bpm)}, \\ &EE_{sit} = 1\text{ BMR} / (24 \times 60), \\ &HR_{low} = 0.6036 \times HR_{max}, \\ &EE_{low} = 0.4 \times EE_{max}, \\ &HR_{high} = (0.8048 + 0.001343 \times VO_{2max}) \times HR_{max}, \\ &EE_{high} = 0.75 \times \text{A}EE_{max}, \\ &HR_{max} \text{ is measured empirically (or } 220 - age), \\ &EE_{max} = 0.00517 \times weight \times VO_{2max}, \end{aligned} \qquad (2)$$

where we have imposed a fourth data point (HR_{sit},EE_{sit}), where × means multiplication, weight is measured in kg, maximal aerobic capacity VO_{2max} is measured in ml/kg/min, heart rate HR is measured in beats per minute, and activity energy expenditure EE is measured in kcal/min. For the four data points, the subscript on HR and EE refers to whether the intensity is low, high, or maximum, and subscript sit refers to the basic metabolic rate when sitting. We determine the basic metabolic rate BMR (kcal/day) with Schofield's [22] equation

$$1\,BMR = \begin{cases} 15.057 \times weight + 692.2 \text{ if male and } 18 \le age < 30 \\ 14.818 \times weight + 486.6 \text{ if female and } 18 \le age < 30 \end{cases} \qquad (3)$$

and VO_{2max} with Jackson *et al.*'s [23] equation

$$\begin{aligned} &VO_{2max} = 56.363 + 1.921 \times PAR - 0.381 \times age - 0.754 \times BMI + 10.987 \times gender, \\ &BMI = \text{weight} / \text{height}^2, \\ &PAR = 7 \text{ if: Participates regularly in heavy physical exercise, i.e. runs more than 10 miles per week or spends more than 3 hours per week in comparable physical activity}, \end{aligned} \qquad (4)$$

where height is measured in meters, gender is 0 for females and 1 for males, and physical activity rating PAR is determined from http://www.topendsports.com/testing/pa-r.htm.

The activity energy expenditure EE is determined by piecewise linear interpolation through the four data points (HR_{sit},EE_{sit}), (HR_{low},EE_{low}), (HR_{high},EE_{high}), and (HR_{max},EE_{max}), *i.e.*

$$EE = \begin{cases} EE_{sit} + \dfrac{EE_{low} - EE_{sit}}{HR_{low} - HR_{sit}}(HR - HR_{sit}) \ \ if \ HR_{sit} \leq HR \leq HR_{low} \\ EE_{low} + \dfrac{EE_{high} - EE_{low}}{HR_{high} - HR_{low}}(HR - HR_{low}) \ \ if \ HR_{low} \leq HR \leq HR_{high} \\ EE_{high} + \dfrac{EE_{max} - EE_{high}}{HR_{max} - HR_{high}}(HR - HR_{high}) \ \ if \ HR_{high} \leq HR \leq HR_{max} \end{cases} \quad (5)$$

The first row in equation (5) is a linear curve from the first to the second data point. The second row in equation (5) is a linear curve from the second to the third data point. The third row in equation (5) is a linear curve from the third to the fourth data point.

To measure differences between the mean %HRmax and EE in the four training sessions, we used a two-way repeated measures multivariate ANOVA test. To enable pairwise comparisons for this data, the Bonferroni correction for four tests was used for Hypotheses 1-4. To test if %HRmax significantly exceeded specific values for Hypotheses 5-8, a one-sample t-test was used. We used mean values and 95% confidence interval to determine the lower and upper bounds in Hypotheses 5-8. The data is presented as means ± standard deviation (SD). A P-value of less than 0.05 was regarded as statistically significant. All statistical analyses were performed using PASW Statistics 18 for Windows (IBM Corporation, Somers, NY, USA).

Results

Figure 1 shows the mean and standard deviation of %HRmax, and the energy expenditure EE using method A (curve A) and method B (curve B). For zumba we observe the warmup period with increasing %HRmax and mean EE as time increases, and the cooldown period with decreasing %HRmax and mean EE as time increases. The drop in both %HRmax and mean EE after 32 min is due to a switch in zumba activity and short rest where the participants drank water. After 14 min, 21 min, and 44 min, less significant drops can be observed due to brief rests lasting less than one minute. Across all four sessions method A predicts the largest energy expenditure when EE<11.6 kcal/min, and method B predict the largest energy expenditure when EE>11.6 kcal/min. This is especially observable at the high peaks where the B curves (filled circles) are higher than the A curves (filled boxes). The two methods are most similar when EE<11.6 kcal/min, and thus the two EE curves almost overlap for zumba. The difference is more pronounced when EE>11.6 kcal/min, as observed for the three other sessions. For 4x4 running and 4x4 spinning, the four intervals are clearly distinguishable. For pyramid running the seven intervals are clearly distinguishable. The participants were encouraged to exert extra during the seventh interval, observable with a mean 14.3 kcal/min (Figure 1).

Tables I, II show the mean %HRmax±SD and mean EE±SD using method B for the four sessions in their entirety, for various parts, the minimum mean %HRmax during recovery, and the maximum mean %HRmax during activity (Tables I, II).

Applying the multivariate ANOVA test, for Hypotheses 1, 3 and 4 the difference is significant with P<0.001 and F= 6.86, and for Hypothesis 2 the difference is significant with P<0.001 and F= 15.74.

Applying the Bonferroni correction caused the following results: For Hypothesis 1, the mean %HRmax during 60 min of zumba was 10.1% lower than during 45 min of 4x4 running (P=0.01). The EE in kcal/min was 13.9% lower in zumba compared to 4x4 running (P=0.01).

For Hypothesis 2, during 60 min zumba the participants used in average 592 kcal (SD: 161), which was 14.2% higher than during 45 min 4x4 running burning 518 kcal (SD: 103, P=0.019).

For Hypothesis 3, the %HRmax during 45 min 4x4 running was 2.5% higher than during 45 min 4x4 spinning (P=0.017), and the participants had 3.5% lower EE in 4x4 spinning than in 4x4 running (P=0.023).

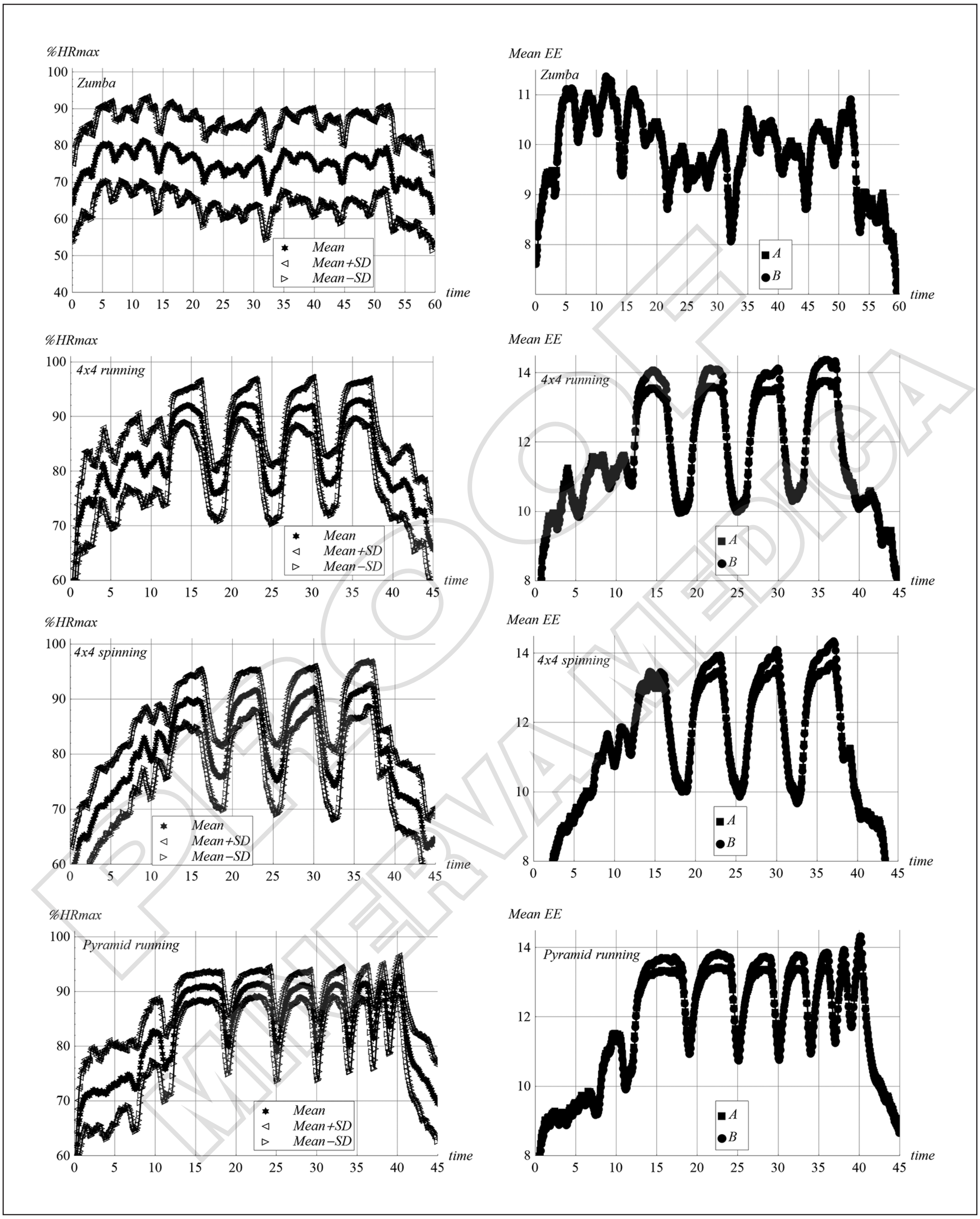

Figure 1.—Percentage of maximal heart rate (% HRmax) and mean energy expenditure (Mean EE) in kcal/min during the four sessions.

For Hypothesis 4, the mean %HRmax during the entire pyramid running session was only 1.1% higher than for 4x4 running, with a high P=0.104. The mean EE in kcal/min during pyramid running was 1.8% higher than in 4x4 running, also with a high P=0.101.

TABLE I.—*Mean %HRmax (percentage of maximal heart rate) ±SD (standard deviation) during 60 min continuous zumba and during three 45 min sessions with 4x4 running, 4x4 spinning and pyramid running, using method B. See text for P-values.*

	Zumba	4x4 running	4x4 spinning	Pyramid running
12 min warmup	76.6±11.0	77.4±6.5	73.7±6.3	74.1±6.6
Recovery periods	75.3±11.7	81.1±4.9	81.2±5.1	86.9±3.6
Activity periods		90.1±3.9	88.5±4.6	88.8±3.2
5 min cooldown	67.8±11.1	74.0±6.2	69.2±5.8	77.9±5.9
Entire	74.9±10.7	82.5±3.3	80.5±3.7	83.4±2.8
1. recovery mean minimum		73.6±4.5	74.2±5.7	80.1±4.7
2. recovery mean minimum		73.5±4.8	74.3±6.0	79.5±4.3
3. recovery mean minimum		75.2±4.5	73.3±6.2	79.7±4.2
4. recovery mean minimum		75.6±4.7	74.3±5.2	80.2±4.5
5. recovery mean minimum				81.6±4.4
6. recovery mean minimum				83.2±4.4
1. activity mean max		93.2±2.8	90.9±4.2	92.0±2.5
2. activity mean max		93.5±2.5	92.0±3.6	92.2±2.3
3. activity mean max		93.4±3.1	92.2±3.9	91.8±2.4
4. activity mean max		94.0±3.3	93.1±4.0	92.0±2.3
5. activity mean max				92.2±2.4
6. activity mean max				91.8±2.8
7. activity mean max				92.8±3.2

TABLE II.—*Mean energy expenditure in kcal/min±SD using method B in four different training sessions. See text for P-values.*

	Zumba	4x4 running	4x4 spinning	Pyramid running
12 min warmup	10.2±3.1	10.3±2.5	9.6±2.3	9.5±2.2
Recovery periods	9.9±3.0	11.2±2.6	11.3±2.6	12.6±3.0
Activity periods		13.5±3.2	12.8±2.8	13.1±3.1
5 min cooldown	8.3±2.6	9.5±2.2	8.7±2.2	10.5±2.7
Entire	9.9±2.3	11.5±2.3	11.1±2.5	11.7±2.4

To test Hypotheses 5 and 6 we determined the minimum %HRmax that each participant reached during each recovery period, and determined the mean of this minimum for the 26 participants. We refer to this as mean minimum %HRmax, with associated SD, in rows 6-11 in Table I. Analogously, we determined the maximum %HRmax that each participant reached during each activity period, and the mean of this maximum, referred to as mean max %HRmax, at the bottom of Table I (rows 12-18).

For Hypothesis 5, except for the first activity period in the 4x4 spinning, the participants' mean max %HRmax significantly exceeded 90% in all activity periods in both 4x4 running and 4x4 spinning (P<0.01), with a mean of 93.5%±2.7% and 92.1%±3.7% for 4x4 running and 4x4 spinning, respectively. During the 3 min recovery periods the participants' mean minimum %HRmax significantly decreased below 78% in all four recovery periods for both 4x4 running and 4x4 spinning (P<0.05), and the mean minimum %HRmax in 4x4 spinning was 74.0%±5.2%, which was not significantly different from mean minimum %HRmax in 4x4 running.

For Hypothesis 6, there were no large differences between 4x4 spinning and 4x4 running in the mean minimum %HRmax in the recovery periods, and in the mean max %HRmax in the activity periods. The largest difference was found in the first activity period where the mean max %HRmax was 2.5% lower in 4x4 spinning than in 4x4 running (P=0.011; Table I).

In pyramid running the participants' mean max %HRmax exceeded 90% in all seven activity periods (P<0.01), with an average of 92.1%±2.3% of HRmax. During the one min recovery periods in pyramid running, the mean minimum %HRmax significantly decreased below 86% in all six recovery periods

(P<0.05), and the participants' mean minimum %HRmax was 80.7%±4.1%.

For Hypothesis 7, the participants' mean minimum %HRmax during the recovery periods in pyramid running was 8.4% higher than the mean minimum %HRmax during the recovery periods in 4x4 running (P<0.001).

For Hypothesis 8, the participants' mean max %HRmax during the activity periods in pyramid running was 1.8% lower (P<0.001) than the mean max %HRmax during the activity periods in 4x4 running.

Discussion

The main findings of the study were that the EE per min was lower during zumba compared to the interval sessions, in which there were no large differences in EE. Further, the mean minimum %HRmax in pyramid running was 8.4% higher than in 4x4 running, while there were no large differences in the mean max %HRmax in these exercise sessions.

Rejection of Hypothesis 1 means that the participants have lower mean %HRmax and mean EE during zumba than during 4x4 running. We interpret this to mean that zumba is a lighter form of training. The result may be partly influenced by zumba lasting 15 minutes longer, and possibly influenced by many of the participants being inexperienced with Zumba and thus not exercising full range of movement. Our %HRmax 74.9±10.7 can be compared with Luettgen *et al.*'s (17) slightly higher %HRmax 79±7 for 19 experienced Zumba participants, but their session was substantially shorter, 38:48±4:53 (min:sec). Our mean EE 9.9±2.3 kcal/min is remarkably similar to Luettgen *et al.*'s (17) mean EE 9.5±2.69 kcal/min.

Rejection of Hypothesis 2 means that the participants have higher EE during 60 min zumba than during 4x4 running. This is caused by zumba lasting 15 min longer which outweighs the lower mean EE of zumba.

Rejection of Hypothesis 3 means that 4x4 spinning has slightly lower %HRmax and EE than 4x4 running. We think this is due to spinning not utilizing the upper body in the same manner as running.

Rejection of Hypothesis 4, with high P-values P=0.104 and P=0.101, means that pyramid running and 4x4 running do not have significantly different mean %HRmax and EE. Although pyramid running has marginally higher mean %HRmax and EE than 4x4 running, the difference is not significant. Hence pyramid running and 4x4 running can be perceived as similar.

Rejection of Hypothesis 5 means that the participants decreased their %HRmax below 78% during the recovery periods in 4x4 running and 4x4 spinning. The three minutes of recovery thus accomplish at least 13% decrease in %HRmax from above 90% to below 78%, which is a reasonably good decrease.

Rejection of Hypothesis 6 means that the participants decreased their %HRmax below 86% during the recovery periods in pyramid running. Hence only one minute of recovery accomplishes only at least 4% decrease in %HRmax from above 90% to below 86%, around 1/3 of the decrease accomplished by three minutes of recovery. This result may also be influenced by the first activity period lasting 6 minutes for pyramid running, as opposed to 4 minutes for 4x4 running.

Rejection of Hypothesis 7 means that the participants decreased their %HRmax during the recovery periods in pyramid running to a level more than 8.4% above the minimum %HRmax during the recovery periods in 4x4 running. This reinforces and quantifies the insight from Hypotheses 5 and 6 of the kind of decrease in %HRmax that is accomplishable by one minute recovery instead of three minutes of recovery.

Rejection of Hypothesis 8 means that the participants increased their %HRmax during the activity periods in pyramid running to a level more than 1.5% below the maximum %HRmax during the activity periods in 4x4 running. It is surprising that the participants reach almost as high maximum %HRmax during pyramid running compared with 4x4 running, given that they have significantly shorter recovery periods and 37.5% longer activity periods. This indicates that one minute recovery period is sufficient to be able to complete the entire interval program in a high %HRmax, and that longer recovery periods may be unnecessary.

Summing up, zumba 60 min has higher EE than the three other sessions lasting 45 min, but has lower %HRmax and EE measured per minute. 4x4 spinning has slightly lower %HRmax and EE than 4x4 running. Pyramid running has slightly higher mean %HRmax and EE during the entire session than 4x4 running. Even though the recovery periods in pyramid running are only 1 min, this seems sufficient since there is only a small difference to 4x4 running in %HRmax in the activity periods. The longer activity periods (22 min vs 16 min) and the shorter recovery periods (1 min vs 3 min) imply lower %HRmax and EE during activity and higher %HRmax and EE during recovery. Future research should focus on whether pyramid running is psychologically different from 4x4 running in that the activity periods shorten as the participants get more exhausted, and should compare with pyramid running where the activity periods gets successively longer as opposed to successively shorter.

Conclusions

Some earlier studies have analyzed energy expenditure for various pure training forms such as step aerobics, weight lifting, etc.[1-4, 9-11, 13, 24] Helgerud *et al.*[15] have analyzed the overall impact of various forms of intervals. This paper proceeds beyond these contributions. First, we consider zumba which has hardly been analyzed. Second, we compare zumba with three forms of intervals; running 4x4, spinning 4x4, and pyramid running. Third, we explicitly analyze the time factor through the sessions. Fourth, we analyze how heart rates decrease during 3 min vs 1 min recovery periods. Fifth, we scrutinize how heart rates increase during short vs long activity periods. These five kinds of insights impact how consumers choose between training forms, and impact how producers design and advertize training forms for various purposes.

This study provides several benefits for coaches and end users. First, we provide a framework and reference point for how exercise programs can be evaluated and compared in terms of energy expenditure for different kinds of activities; zumba without intervals, spinning with intervals, and running with two kinds of intervals. Program developers may test activities linked to different objectives. For example, if pyramid running proves too strenuous, the recovery periods may be increased above 1 min or pyramid running may be substituted with 4x4 running. To increase EE or to train at higher intensity levels, the recovery periods in 4x4 running and spinning may be shortened since 1 min recovery seems satisfactory to manage a high %HRmax in pyramid running. Using energy expenditure as a common denominator, we show how the intervals and recovery periods are compared with each other, and with jogging at different speeds. Second, we show how heart rate monitors conveniently allow for calculating energy expenditure. Third, we illustrate how exercise programs can be assessed quantitatively which we consider advantageous when linking exercise programs to objectives such as improvement in cardiovascular fitness and performance.

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