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Original Article

Energy expenditure in women boxing

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Abstract
Objectives: Women boxing have got recognition recently and so far no work has been reported on energy expenditure of national women boxers in India. This study was aimed to estimate the energy expenditure in Indian female boxers during sparring.
Methods: A total of 20 female boxers were subjected. Energy expenditure was estimated using the same individual's HR-VO_2 regression equation. Heart rate was recorded through radiotelemetry.
Results: Results reveal that average and maximum energy expenditure considering the total duration of boxing are12.7 +/- 1.3 and 14.4 +/- 1.6 kcal/min.
Conclusions: It is concluded that depending on the severity of energy expenditure female boxing comes under heavy category and as it is a pioneer attempt in India, further studies in this aspect are really required which will guide the coaches regarding the energy expenditure pattern in women boxing.

Key words: Female boxing, Combat sports, India, Energy cost

The evaluation of the sport of boxing has brought more attention to effective training methods than other martial arts have received. In India investigations have been carried out on male boxers[1]. But women boxing have got recognition recently, so far no work has been reported on women boxers in India. Energetics of different combat sports like Taekwondo, karate has been studied[2,3]. Pattern of energy expenditure of any sport is of utmost importance to the coaches to adopt proper nutritional strategy and thereby a justified training plan. Hence, this study was undertaken as a pioneer attempt to quantify the energy demand in the sport of women boxing.

Heart rate bears a linear relationship with energy expenditure is now an established fact[4,5]. Hence it is possible to estimate the energy expenditure from the heart rate and VO_2 during match play provided the regression equation of heart rate and VO_2 consumption of the same athlete is determined first in the laboratory. In the same way, Coad *et al*[6] has shown the feasibility of monitoring the heart rate to estimate the energy demand of singles and doubles of badminton. Boyle *et al*[7] has shown the energy cost of elite hockey. Study has been made by Ghosh *et al.* to estimate the energy cost of female field hockey following the same procedure[8].

The present study was aimed to estimate the energy expenditure of the game, which would certainly guide the coaches and other sports medicine specialists regarding the energy expenditure pattern in female boxing.

Materials and methods

Subjects: A total of 20 female boxers (aged between 17~24 years) volunteered to participate. Subjects were selected from first Senior Women National Camp. Prior to acceptance as subject a complete physical examination was required to determine good health status of the subjects. The tests were demonstrated to the subjects before actual administration and they agreed to sign a statement of informed consent. All institutional policies concerning the human subjects in research were followed.

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Experimental Design: Laboratory tests and heart rate monitoring during sparring of each subject was conducted at an interval of 4 days by random sequencing. Laboratory test was followed by boxing sparring in the half of the subjects whereas boxing sparring was followed by laboratory test in other half of the subjects to avoid any possibility of bias. Treadmill testing and testing during sparring was conducted in the same menstrual cycle phase for each individual boxer to avoid differences due to menstrual cycle phase.

The nature of the sparring sessions was open. No constraints were placed on the spar, similar to a contest.
In the boxing hall where sparring was organized the temperature and relative humidity was 23-25^{0}C and 50-60% respectively.

Procedure: Tests were conducted in two phases.
Phase 1: Oxygen consumption and heart rate (HR) were measured through graded treadmill exercise (Jaeger & Co., Germany). The initial speed of the treadmill was 8 km/hr with an inclination of 2% and thereafter the speed was increased by 2 km/hr after every 2 minutes until a plateau of VO_2 was attained or the respiratory quotient value (RQ) exceeded 1.15. The whole experiment was performed at room temperature varying from 23-25^{0}C with the relative humidity varying between 50-60%[9].

Phase 2: 20 Boxing sparring were organized among different pair of boxers. Each sparring was of 3 rounds, each round of 2 minutes duration with recovery time of 1 minute in between. In each sparring pair only one individual was subjected for heart rate monitoring to avoid overlapping. The heart rate of each boxer was measured continuously at 5 s intervals during all the rounds using Sport Tester PE-3000 system (Polar Electro, Finland). The data stored in the memory of watch were then downloaded to a computer and evaluated using proprietary software (Polar Electro, Finland).

HR-VO_2 Regression Equation: Regression equation of VO_2-HR was calculated to estimate indirectly the oxygen consumption from heart rate[10,11]. Telemetered heart rate values during boxing sparring were obtained and their corresponding VO_2 were used to estimate the oxygen uptake during sparring. The high correlation coefficients are ordinarily obtained between HR-VO_2[12]. The relationship between energy expenditure and heart rate is more linear if limited to an individual rather than group[13] and in the present study individual equation was established first for prediction of energy expenditure. The energy expenditure of each boxer was estimated using the same individual's HR-VO_2 regression equation.

Calculation of Energy Expenditure: Studies with the bomb calorimeters have shown that approximately 4.82 kcal of heat are liberated when a blend of carbohydrate, fat and protein is burned in one litre of oxygen. The calorific value for oxygen varies only slightly even with large variation in the metabolic mixture. Assuming, the consumption of a mixed diet, for convenience in calculation, a value of 5 kcal/litre of oxygen consumed can be used as an appropriate conversion factor for estimating the body's energy expenditure[14]. We followed the same for the present study as the boxers maintained a mixed diet during the experimental period.

Statistical Analysis: All the values are expressed as Mean +/-Standard Deviations. To find out the significance of changes in energy expenditure between and within the rounds of boxing one-way ANOVA followed by Post-Hoc LSD (least significant difference) was used. Statistical Package for social sciences (SPSS) MS Windows Release 6.1 was used for statistical analysis.

Results

The 20 women boxers had a mean age of 19.7 +/-2.2 yr., body height of 159.9+/-4.8 cm, and body weight of 56.6 +/-7.1 kg. Fig. 1 exhibits the HR-VO_2 relationship in a single boxer. The regression co-efficient in this case was 97.8% and it varied from 95.5 to 99.7% among the boxers.

Table 1 depicts the heart rate and energy expenditure in boxing sparring for the 1st, 2nd and 3rd rounds (including total duration).

Table 2 depicts the results of one-way ANOVA for average energy expenditure during 3 rounds of boxing. Table 3 depicts the post hoc multiple comparisons for average energy expenditure during 3 rounds of boxing.

From the table I it reveals that average expenditure in 1st, 2nd and 3rd round of boxing were 11.6 +/- 2.0, 12.9 +/-1.3 and 13.3 +/- 1.3 kcal/min respectively. Considering the total duration of sparring average and maximum energy expenditure were 12.7 +/- 1.3 kcal/min and 14.4 +/-1.6 kcal/min.

Table 1: Heart Rate and Energy Expenditure During 3 rounds of Boxing (Mean ±SD)

Parameters	Round 1	Round 2	Round 3	Total duration
Average Heart Rate (beats/min)	171±11	181±8	184±7	179±8
Maximum Heart Rate (beats/min)	183±6	189±6	193±7	193±7
Average Energy Cost (kcal/min)	11.6±2.0	12.9±1.3	13.3±1.3	12.7±1.3
Maximum Energy Cost (kcal/min)	13.1±1.5	13.8±1.5	14.4±1.6	14.4±1.6

Table 2: One-way ANOVA for Average Energy Expenditure (kcal/min) in Three Rounds of Boxing

Variable	Source	Degree of Freedom	Sum of Squares	Mean Squares	F Ratio
Average Energy.	Between groups	2	31.61	15.80	6.49
	Within groups	57	138.77	2.43	
	Total	59	170.38		

Significant at 0.05 level
D.F. (2,57) = 4.98

Table 3: Post-Hoc Multiple Comparison of Average Energy Expenditure (kcal/min) in 3 Rounds of Boxing

Rounds			Difference
Round 1	Round 2	Round 3	
11.6	12.9		1.3*
11.55		13.3	1.7*
	12.9	13.3	0.4

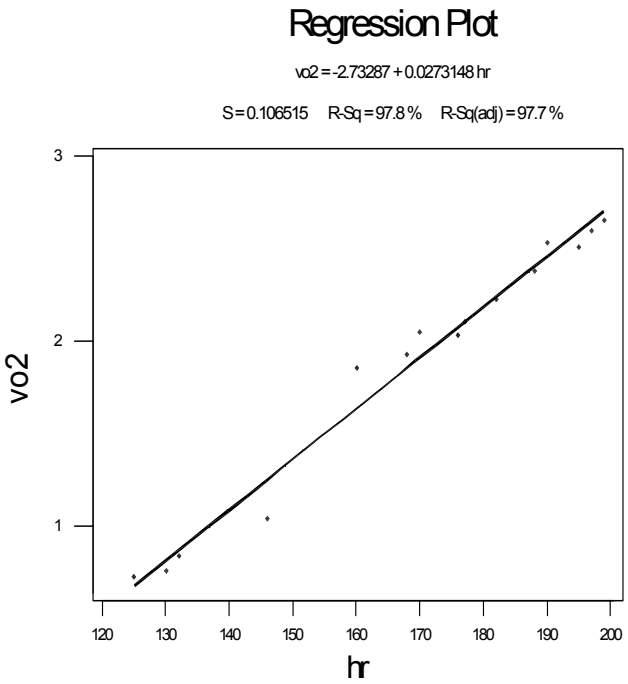
*Significant at 0.05 level
CI = .99

Table 4: One-way ANOVA for Maximum Energy Expenditure (kcal/min) in Three Rounds of Boxing

Variable	Source	Degree of Freedom	Sum of Squares	Mean Squares	F Ratio
Maximum Energy Cost	Between groups	2	15.98	7.99	3.38 NS
	Within groups	57	134.66	2.36	
	Total	59	150.65		

D.F. (2,57) = 4.98
NS= Not significant

Fig 1: Relationship between VO_2 and Heart Rate in an Individual Boxer



Discussion

It is very clear from table I that energy expenditure depend upon the intensity of sparring. It is observed that in 3rd round the boxers expended the highest amount of energy. Average energy expenditure shows a gradual increment from round 1 to round 3. Significant increase ($P<0.05$) in average energy expenditure is observed in between the round 1-2 and round 1-3 but in between round 2 and 3 this difference is not statistically significant. In maximum energy expenditure no significant difference is observed in between the rounds (Table 3).

Data on energy demand of women combat sport are scanty in the literature. Hence, there is no option left but to compare the demand of female boxing with that of male combat sports though it is a fact that physiological variables in females differ from those of males. After Reilly, 1981[15] energy cost of various combat sports are as follows-Boxing-46-60 kJ/min, Judo-41-55kJ/min, Wrestling50-59 kJ/min, and Fencing 21-42 kJ/min.

According to Reilly, depending on severity of energy cost, games are categorized into light, moderate, heavy and very heavy. Boxing, Judo, Wrestling come under heavy category and Fencing under moderate category. In our study the women boxer's average energy expenditure is 53.3 kJ/min (12.7 kcal/min), which is in the heavy category. A study conducted on men and women volunteers participating in randomized fitness boxing trials reported energy expenditure values ranging from 9.8 to 11.2 kcal/min[16]. In another combat sport of Dynamic Taekwondo, studies on experienced women have shown an average energy expenditure of 10.8 kcal/min[2]. According to a study[17] in boxing sparring mean energy expenditure is 12.4 kcal for 56-59 kg wt. group; our women boxers had a mean body weight of 56.6 kg. The same study reported that in boxing sparring per kg of body weight mean energy expenditure is .222 kcal/min. In our study this value is .220 kcal/min.

Conclusions

The study reveals that in Women Boxing the amount of energy expenditure is comparable with their male counterparts of the same weight category. Considering the energy cost of the sport, practice hour and other activities coaches can guide the boxers to an energy intake, which matches the expenditure.

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