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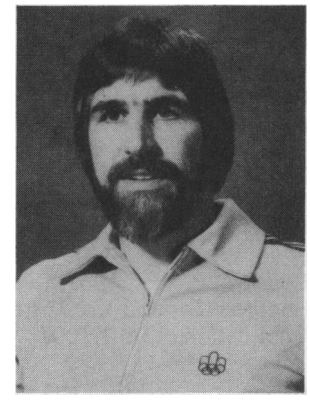
A COMPARISON OF HEART RATE RESPONSES IN RACQUET GAMES

D. DOCHERTY, PhD

School of Physical Education, University of Victoria, Victoria, B.C., Canada



D. Docherty

ABSTRACT

The present study investigated the heart rate response to playing tennis with special reference to the skill levels and ages of the participants. Data obtained in a similar manner during earlier studies of badminton and squash players were compared with that obtained during tennis. The number of rallies, mean rally time and actual playing time in 30 minutes of play was also compared for the different skill levels and sports.

Results showed that playing tennis raised the players' heart rates to 68-70% of their predicted maximum heart rate (PMHR). Playing squash and badminton could raise heart rates to 80-85% of the players' PMHR which was significantly higher than the values obtained for tennis. The actual skill level of the participants within their chosen sport did not have a significant effect in predicting the physical demands of squash or tennis but was important in predicting the heart rate response of badminton players. The more skilful the badminton player the greater the cardiac response as a result of game play.

Analysis of time spent in actual play revealed that tennis players were involved in play for only five of the thirty minutes of game play, compared to 15 and 10 min respectively for squash and badminton. Skill level within each sport was only a significant factor in predicting length of play for squash players in which the medium and highly skilled groups played significantly longer than those of a lower level of skill.

INTRODUCTION

Many individuals are seeking alternative forms of exercise to running and swimming as a means of developing or maintaining a degree of physical fitness. Sports and games are frequently selected in the expectation that they will provide sufficient intensity and duration to elicit training effects, especially on the cardiovascular system. Several authors have stated that optimal training effects are obtained when stress levels produce 75-85% of the individual's maximum heart rate or 50-85% of $\dot{V}O_2$ max (Åstrand, 1974; Lavoie, 1977 and ACSM, 1978). Lower work intensities have achieved significant gains in $\dot{V}O_2$ max but only for subjects with an initial aerobic capacity of less than 35 $ml.kg^{-1} min^{-1}$ (Wenger and MacNab, 1975).

Several investigators have examined changes in the cardiovascular and metabolic systems of individuals engaged in a variety of team sports (Paterson et al, 1977, among others, mentioned in his references). Few studies, however, have examined similar effects during individualised sports such as badminton, tennis and squash. Considering the recent interest in racquet sports it would be desirable to examine the physiological effects of these games upon players, to provide information useful to counselling individuals to select activities appropriate to the type of benefits they wish to derive through participation.

Blanksby, Elliott and Bloomfield (1972; 1973), examined telemetred heart rate responses during squash, and indicated that playing squash elevated heart rates to 153 bpm for middle-aged active men, 174.8 bpm for the middle-aged sedentary and 162.7 for "A" grade players.

Heart rate of players during a 20 min game of tennis, badminton and table tennis was recorded via telemetry by Rittell and Waterloh (1975), the highest mean heart rate of 175 ± 6 bpm being recorded for badminton players; followed by table tennis players with 174 ± 8 bpm; and tennis players with heart rates of 150 ± 10 bpm. Bartunkova et al (1979) obtained heart rates of

142 to 162 bpm for junior representative players (mean age 18.99 ± 3.05 y) during a 10 min game of badminton, which represented 70-80% of the predicted maximum heart rate (PMHR). The oxygen consumption during game play reached 1.9 ℓ/min or 52 per cent of $\dot{V}O_2$ max, and an average caloric expenditure of 37.7 $J.min^{-1}$ (9 kcal/min). Bartunkova et al (1979), from a previous study, reported lower heart rates from participation in tennis (143 bpm) but a higher caloric expenditure of 43.5 $J.min^{-1}$ (10.4 kcal/min).

Misner et al (1980) monitored the heart rate of 28 men, ranging in age from 23-52 y, playing recreational tennis, and of uniform and average ability. Their average subject achieved a mean heart rate of 60% of the age-adjusted maximal exercise heart (AMEHR) for extended periods of tennis play. During their games the ball was in play for 23% of the time but the AMEHR did not show marked fluctuations (in our series, the ball was in play only 17% of the time).

The actual extent and pattern of changes in the cardiovascular system has, therefore, been shown to vary with the type, duration, and intensity of the sport. Actual game characteristics, however, and subsequent physiological demands on the participants, has also been shown to be affected by the skill level of the players. Docherty (1978) found heart rates could be elevated to 80-85% of the player's PMHR during a thirty minute game of badminton and the more skilful players had significantly greater stress placed on their cardiovascular system as reflected by heart rate. A similar study conducted with squash players (Docherty and Howe, 1978) recorded heart rate values at approximately 80% of the individual's PMHR but in squash the degree of stress was independent of skill level.

The present study investigated heart rate response to playing tennis with special reference to the skill levels and ages of the participants, with data obtained during earlier studies of badminton and squash players used for comparison. The number of rallies, mean rally time and actual playing time in 30 min of play was also compared for the three sports.

METHODS

Subjects

Forty-two men were placed into one of three groups based upon their previous experience and success in playing tennis. A highly skilled (HS) group was formed of successful "singles" tournament players in Victoria, B.C., or members of the Pacific Northwest Junior Pro-Circuit. Players with considerable experience in recreational and tournament play, but who had not won a major tennis tournament, were classified as the medium skilled (MS) group, and individuals with minimal background and experience in tennis, were placed in the low skilled (LS) group.

Procedures

The Åstrand cycle ergometer test (1967) was administered to all subjects to determine the aerobic fitness level, which could be used as a covariant during data analysis. In this test the subject pedalled at a set workload to reach a heart rate pleateau between 135 and 145 beats/min. Maximal oxygen consumption was predicted from the workload, sex, heart rate, age and body weight.

Within two days of the aerobic fitness test subjects competed in a 30 min singles game against an opponent from the same skill group, following a 10 min warm-up. Heart rate was monitored continuously by a telemetry transmitter system strapped to a belt and held in position on the non-playing side. Adhesive tape and "tuf-skin" held the electrodes in the CM5 position. Heart rate was relayed from the receiver into a standard ECG recorder with a digital readout. The actual heart rate was recorded every 30 s and averaged for each five minutes of play to give time plots for the 30 min game. In order to examine cardiac response relative to the individual's work capacity, heart rate was expressed as a percentage of each individual's predicted maximum heart rate (PMHR) based on age and sex, and served as the criterion for this study. The length of each rally (RT) and the total number of rallies (TR) during the 30 min game were also measured, which permitted computation of mean rally time (MRT). The tennis games were played out of doors, at temperatures that were consistently between 70° and 75°F (21° and 24°C). The indoor games were played at similar temperatures. The humidity of Victoria is low.

RESULTS

The means and standard deviations for the descriptive data for the tennis players are presented in Table I. Skill groups for tennis were not different ($p < 0.05$) in age, weight, aerobic fitness and the rally times recorded during the 30 min of game play.

TABLE I

Age, weight, aerobic fitness and game characteristics of skill groups in tennis reported as X ± s

VARIABLE	SKILL LEVEL L.S.	M.S.	H.S.
Age (years)	25.78 ± 4.6	24.43 ± 5.7	26.57 ± 6.1
Weight (kg)	75.0 ± 8.2	74.35 ± 11.4	71.36 ± 7.2
Predicted $\dot{V}O_2$ max ($ml.kg^{-1} min^{-1}$)	43.4 ± 7.6	43.9 ± 7.7	44.6 ± 7.3
Total Rally Time (min)	4.90 ± 0.8	5.55 ± 0.8	4.75 ± 0.75
Number of Rallies	69.1 ± 5.9	74.8 ± 7.5	71.4 ± 7.4
Mean Rally Times (s)	4.3 ± 0.6	4.2 ± 0.9	4.0 ± 0.4

Figure 1 shows the mean heart rates for the three skill groups in tennis expressed as a percentage of PMHR and averaged for each five minute playing-period of the game. A two-way ANOVA with percentage of PMHR for each individual as the criterion, and time and skill level as the independent measures, showed that neither skill level, nor an interaction between skill level and time, were significant factors in predicting heart rate response. There was, however, a small but significant effect for the repeated measure of playing time in which heart rate increased from 133 bpm to 137 bpm or from 68% to 71% of the individual's PHMR ($F = 3.45$, $p < .01$).

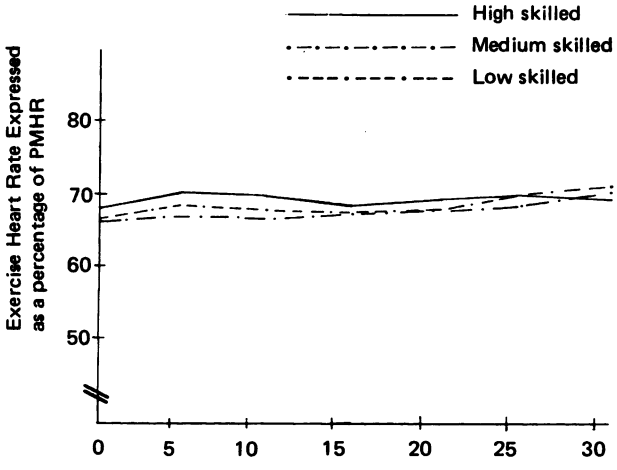


Fig. 1. Mean heart rate responses expressed as a percentage of PMHR for tennis players during a 30 minute game relative to skill level.

The comparison of the basic descriptive data for the three racquet sports, and skill levels within each sport, is presented in Table II. The groups were similar in age and weight, both within and between sports. The highly skilled squash players did have a significantly higher chronological age but were comparable with all other groups of PMHR. The greater chronological age of the highly skilled squash group reflects the structure of the classification system in which players need to win two "recognised" tournaments at a specific ranking to be designated "A" class players. Progress through the ranking system takes time although the increasing popularity of squash among young people will probably produce younger "top-ranked" players.

The actual game characteristics, as expressed by rally time, were consistent for the skill level groups within each sport, with the notable exception of the squash players. Players in the low skilled squash group played for 12 min during the 30 min game, which was significantly less than the respective playing times of 16 min and 17 min recorded for the medium and highly skilled groups ($p < .05$). An inter-sport comparison shows that, with the exception of the lower skilled participants, squash players were involved in rallying for a longer period than the badminton group ($p < .05$). The badminton and low skilled squash groups rallied significantly longer than the three tennis groups ($p < .05$).

The present analysis and the analyses on playing badminton and squash (Docherty, 1978; Docherty and Howe, 1978) showed little functional effect of game duration on heart rate response. In order to compare the cardiac response when playing the different sports relative to skill level, the six initial time plots were further averaged to produce a mean heart rate (expressed as a percentage of PMHR) for each skill group within each sport (see Figure 2).

A two-way ANOVA of skill by sport with heart rate expressed as a percentage of PMHR as the criterion, revealed significant effects for sport ($F = 23.0$, $p < .01$), skill level, ($F = 3.5$, $p < .01$), and sport by skill level ($F = 2.6$, $p < .05$). Observation of Figure 2 and a post-hoc analysis of specific comparisons indicated that

TABLE II

Age, weight and game characteristics for skill level and sport groups (reported as X ± s)

	Tennis			Badminton (42)			Squash (3)		
Variable	L.S.	M.S.	H.S.	L.S.	M.S.	H.S.	L.S.	M.S.	H.S.
Age (years)	25.78 ± 4.6	24.43 ± 5.7	26.57 ± 5.1	24.57 ± 5.4	22.79 ± 3.9	25.43 ± 6.72	24.8 ± 5.6	30.4 ± 5.5	35.60 ± 10.4
Weight (kg)	75.00 ± 8.2	74.35 ± 11.2	71.36 ± 7.2	68.79 ± 7.9	71.43 ± 6.3	66.56 ± 6.7	76.7 ± 7.9	78.10 ± 8.8	77.00 ± 10.6
Total Rally Time (min)	4.90 ± 0.75	5.55 ± 0.80	4.75 ± 0.75	10.01 ± 1.4	9.70 ± 1.8	10.35 ± 1.3	12.25 ± 0.90	16.25 ± 2.1	16.90 ± 1.8
Number of Rallies	69.0 ± 5.9	74.0 ± 7.6	71.0 ± 7.4	129.0 ± 25.65	139.0 ± 16.2	127.0 ± 13.1	139.0 ± 17.4	119.0 ± 13.8	116.0 ± 13.9
Mean Rally Time (s)	4.3 ± 0.6	4.2 ± 0.9	4.0 ± 0.4	4.9 ± 1.3	4.2 ± 0.5	4.9 ± 0.7	4.4 ± 0.8	8.4 ± 1.7	8.8 ± 1.0

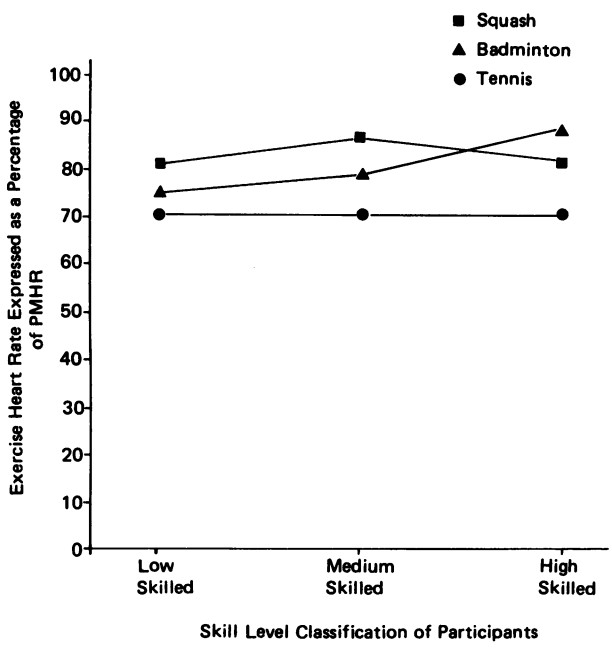


Fig. 2a. Mean heart rate responses of a thirty minute game expressed as a percentage of the PMHR for each sport and skill level.

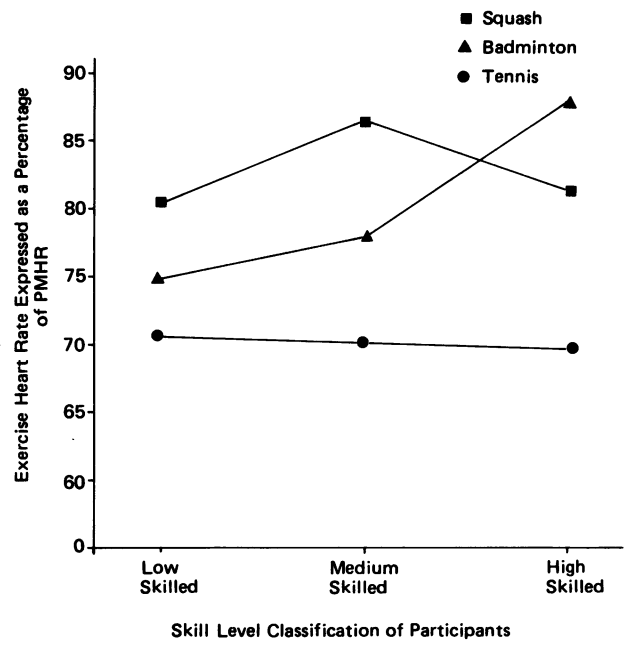


Fig. 2b. Top of graph redrawn to a larger scale.

squash and badminton players had greater heart rate than tennis players with respective F ratios of 19.5 ($p < .01$) and 19.4 ($p < .01$). Although skill level proved a small but significant factor in the overall assessment ($F = 3.5$, $p < .05$), independent analysis of skill within each sport showed the effect to hold true only for badminton where the highly skilled group had significantly greater cardiac response than the medium and low skilled groups. Such a trend is reflected in Figure 1 where a significant interaction effect can be noted ($F = 2.6$, $p < .05$).

DISCUSSION

The analysis of time spent in actual play during the 30 min game period revealed that squash and badminton players rallied for 15 and 10 min respectively. Tennis players rallied for five min or 20% of the playing time which is in agreement with the findings of Misner et al (1980). The differences in the time of actual game play reflects both the nature of the physical boundaries in which the three racquet sports are played and the degree of skill complexity.

As squash is played within a walled court, the participant has a greater margin of error whilst keeping the ball in play. A ball that is over hit, or played off centre, will still remain in play whereas similar errors in badminton or tennis would result in the shuttle or ball passing out of the court. In badminton, however, minimal time is lost between the retrieval of the shuttle and subsequent resumption of play. More physical demands, such as speed and strength, are imposed in tennis due to the court size and therefore the fitness level can be limiting. Tennis is also an "open court" game which reduces the margin of error. When an error is made, the court dimensions and lack of a walled constraint result in considerable time being spent on retrieving the ball. The serve in tennis may also be a contributing factor in reducing the actual playing time since at low skill levels it is a difficult skill to master and results in rallies frequently not being started. On the other hand, with higher skill levels the serve can be so effective that it eliminates the possibility of a return volley.

Within each sport, skill level was a significant factor only in predicting the length of rallies for squash players in that the medium and highly skilled groups played significantly longer than the low skilled group. Despite playing for significantly less time the low skilled squash group had a greater number of rallies and shorter mean rally times than the medium and highly skilled groups.

There are several discrepancies and similarities between the present study and previous ones when comparing the physical intensity as measured by heart rate,

for example on badminton and tennis players (Rittel and Waterloh, 1975), (Bartunkova et al, 1979) and for tennis players, Kozar and Hunsicker (1973) and Misner et al (1980).

However, these papers gave inadequate consideration to duration or level and skill in the game, or to the age of the participants.

Using 75% of PMHR as the criterion for maintaining or improving aerobic fitness, the results of our three studies indicate that an individual needs to be selective in the choice of sports. For skilled players the game of badminton offers sufficient activity for fitness maintenance or improvement. Playing squash, however, provides high levels of activity regardless of the playing level of the participants. Tennis may have value in improving or maintaining fitness levels of individuals who are initially low in $\dot{V}O_2$ max but of limited value to individuals above a $\dot{V}O_2$ max of 35 $ml.kg^{-1} min^{-1}$.

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