# BIOMECHANICAL AND PHYSIOLOGICAL MEASURES OF TEEN-AGED BADMINTON PLAYERS

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Badminton books, coaching manuals, and instructional pamphlets all attest to the importance of cardio-respiratory endurance, strength, and flexibility and many provide training methods and schedules. For example, a training schedule for elite badminton players has been compiled by Canada's national team coach, but no norms are provided which would indicate acceptable levels of achievement (Gilliland, 1987). There appear to be no values available to indicate extraordinary, or even acceptable, levels of performance for badminton players. In one of the manuals (the Level III Training Manual of the Canadian Badminton Association by Reed, 1981:29), reference is made to some norms including a badminton four-corner fitness test developed by the University of Ottawa Research Group, that provides heart rate recovery, and recovery speed statistics for adult and junior competitors. However, those norms are specific to the four-corner test and provide only a rough indication of the demand on the cardio-respiratory system.

A search of the research literature revealed that little information is available regarding human performances of badminton players. Several studies have been conducted on badminton players in Denmark, where 100,000 members (about 10% of the total membership) are registered as active within the Danish Sports Association; physical requirements of both recreational and elite players were investigated (Coad, et al, 1979:43; Mikkelsen, 1979:43). No statistics exist (apparently) for teen-aged champions.

## *Purpose*

The purpose of the present study was to identify selected biomechanical and physiological characteristics of a group of elite junior badminton players including provincial and national champions. Specific values for each athlete would be useful in planning individual training programs. Future plans include a retesting of the same population of players for the purpose of evaluating their training programs and the effect of high-level competition.

## *Review of Literature*

Many references have been devoted to the evaluation of human performance variables of athletes. Some of the more useful include: Margaria, Cenetelli, Aghemo, Sassi (1963), Leighton (1966), Saltin and Astrand (1967), Astrand and Rodahl (1970), Komi (1976), and MacDougall (1982). It was on the basis of these references that methods for the present study evolved.

## *Methods*

### Subjects

Ten male and six female teen-aged badminton champions from the Western Ontario Badminton Academy were the subjects. They made up a special high-performance group of Junior athletes chosen from the entire western Ontario regional clubs and represented an age range of 13 to 17 years.

### Tests

In addition to recording of age, height and weight, the following tests were administered.

1. Body Composition: a seven-site skinfolds technique was used to estimate body fat. The summed thickness of the skinfolds from the seven sites was recorded in mm.

2. Maximal Aerobic Power: a treadmill test at speeds of 11.27 to 12.88 km/hr (7.0 to 8.0 mi/hr) was administered at grades ranging from 4% to 10%. Each subject was tested at a specific velocity of run. The grade level was increased 2% after each two-minute interval until the subject was exhausted. Calculations of oxygen consumption were based on the volume and temperature of gas collected, the percentage of oxygen and carbon dioxide in both inspired and expired air, the frequency of respiration, and the barometric pressure. The results were recorded as time at the grade level reached at a certain speed, maximum volume of oxygen consumed in 1/min and corrected as ml.kg.min and maximum heart rate in beats per minute. Protocol for

the test was identical to the procedure described in MacDougall (1987:55)

3. Anaerobic Capacity (tolerance to lactic acid): this test was a run for time on a treadmill which was set for 16.10 km/hr for males and 14.49 km/hr for females (10 and 9 mi/hr, respectively) at a 16% elevation. The results were recorded in total seconds of tolerance time, as well as the plasma lactic acid concentration in blood samples taken five minutes after the cessation exercise.

4. Strength: maximal single leg press strength for each leg was measured on a Cybex dynamometer at velocities of 15 and 75 degrees/s. Strength was measured as peak torque and expressed absolutely in Nm. Strength measures were corrected to reflect amount of body mass and expressed in units of Nm/kg.

Maximal shoulder rotation strength was measured on the Cybex by using a specially adapted bar at velocities of 30 and 300 degrees/s. Both medial and lateral rotation strength of the dominant arm were monitored from a position in which the shoulder was abducted 90 degrees and the elbow was flexed 90 degrees. At the lower velocity strength was measured as peak torque and expressed absolutely in units of Nm. At the higher velocity strength was measured as impact torque because of the variability of the torque trace at this speed.

Maximal pronation and supination strength was also measured on the Cybex by use of a specially adapted bar. The dominant forearm was used at velocities of 30 and 300 degrees/s. Measures were recorded identically to the procedure indicated for shoulder rotation.

5. Flexibility: Measures of range of motion at 18 different joints were accomplished by using the Leighton flexometer and following the procedures outlined by Leighton (1966). The following joints were selected for measurement: for the upper extremity, flexion/extension, abduction/adduction, and rotation at the shoulder joint, flexion/extension at the elbow joint; supination/pronation at the radio-ulnar joints and flexion/extension, and ulnar and radial flexion (abduction/adduction) at the wrist; for the lower extremity, flexion/extension at the hip joint, flexion/extension at both right and left knees, dorsi-/plantar flexion at the right and left ankles, and inversion/eversion at the right and left ankles; and for the axial skeleton, flexion/extension at the "neck", flexion/extension, lateral flexion, and rotation of the "trunk".

There is no record of flexibility tests being administered to badminton players, but results were compared with some of the norms available from other populations. Similarly, no physiological tests employing a similar protocol could be found and no results were available on badminton players, especially teen-agers. Results were compared with those of subjects who experienced a similar protocol who were members of the Junior National Soccer Team.

## *Results*

The average age of the ten male subjects was 14.5 years while for the females, it was 14.67 years. The males weighed an average of 60.25 kg and the females 56.55 kg. The males stood at a height of 168.65 cm and the females 161.58 cm.

1. Body Composition: the summed thickness of the seven sites averaged 80.49 mm for males and 129.97 mm for females and ranged from 44.1 mm to 172.0 mm.

2. Maximal Aerobic Power: the mean value of maximum $VO_2$ uptake was 3.38 l/min for males and 2.70 l/min for females, (56.34 ml.kg.min -1 and 47.28 ml.kg.$min^{-1}$ respectively). Heart rate maxima averaged 202.4 beats per minute for the boys and 201.33 beats per minute for the girls.

3. Anaerobic Capacity: the mean exercise time was 28.8 s for males and 24.3 s for females with time ranging from 18 to 41 s. The mean lactate concentration was 9.49 mMol/1 for males and 8.98 mMol/1 for females and ranged from 6.0 to 13.3 mMol/1.

4. Strength: maximal single leg press strength for the right leg, at a velocity of 15 degrees/s averaged 490.4 Nm for the males and 449.0 Nm for the females. At a velocity of 75 degrees/s, the means were 417.4 Nm and 373.0 Nm, respectively. Maximal leg press strength for the left leg was lower for all conditions. The mean for the males at a velocity of 15 degrees/s was 480.6 Nm, while that for the females was 410.3 Nm. At a velocity of 75 degrees/s, the means were 407.0 Nm and 334.7 Nm, respectively.

When each of the leg press values were corrected for body mass, the results were as recorded in Table 1. As was found in the absolute values, the maximal leg press strength was greater for the right leg.

Table 1. Maximal Single Leg Press Strength Per Kg Body Mass (Nm/kg)

| | RIGHT LEG | | LEFT LEG | |
|---|---|---|---|---|
| | 15 o/s | 75 o/s | 15 o/s | 75 o/s |
| Mean for Males | 8.13 | 6.98 | 7.89 | 6.75 |
| Mean for Females | 7.99 | 6.60 | 7.29 | 5.92 |

Maximal shoulder rotation strength was measured as peak torque at 30 degrees/s and as impact torque at 300 degrees/s. The average values for the males when rotating the arm medially and laterally at a velocity of 30 degrees/s were 42.0 Nm and 29.7 Nm, respectively; those for the females were 33. 3 Nm and 24.3 Nm, respectively. At 300 degrees/s, sometimes thought of as power of high-speed strength, the males averaged 78.8 Nm for medial rotation and 47.4 Nm for lateral rotation; the females averaged 51.3 Nm and 39.2 Nm, respectively.

Maximal pronation and supination strength was also measured at low and high velocities. For the males, pronation and supination means for 30 degrees/s were 6.67 Nm and 8.06 Nm, respectively; for the females, the means were 6.30 Nm and 6.94 Nm. At the higher velocity, the means were also higher; for the males, pronation and supination averaged 10.13 Nm and 10.06 Nm, respectively, while for the females, averages were 9.94 Nm and 9.44 Nm, respectively.

5. Flexibility: The results of the eighteen tests of flexibility are presented in figures 1, 2, and 3. In addition to reporting the results of the badminton measures, a comparison with 40 16-year-old boys from the state of Oregon is provided.

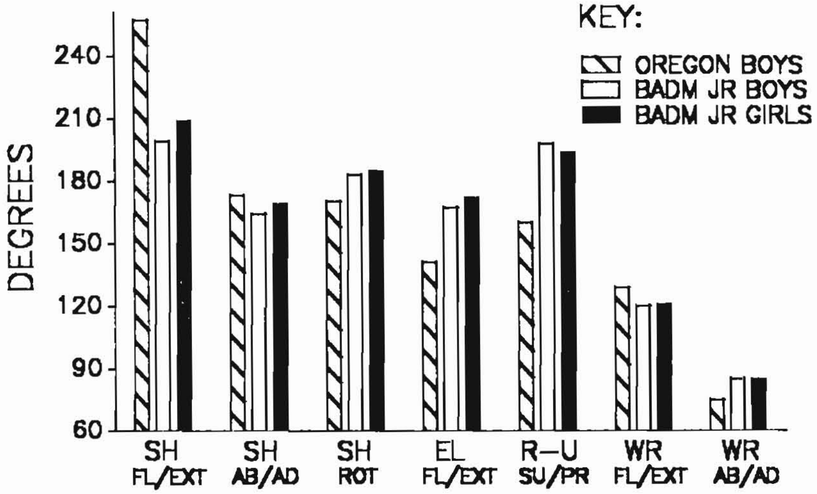


FIGURE 1. FLEXIBILITY — UPPER EXTREMITIES

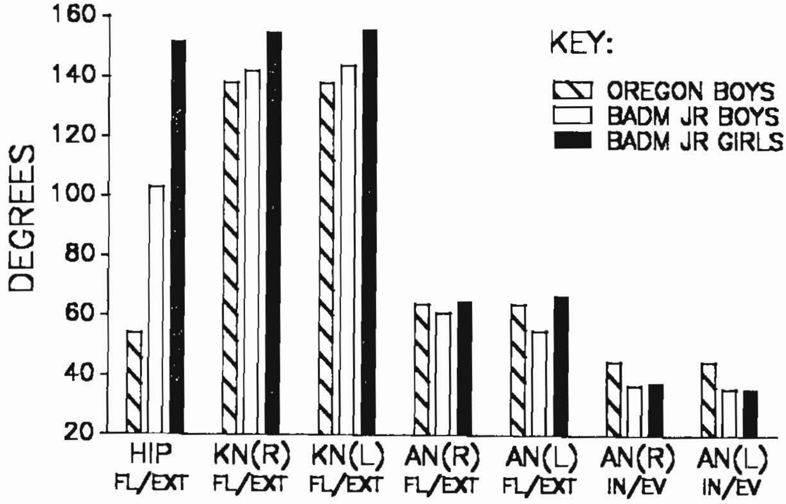


FIGURE 2. FLEXIBILITY — LOWER EXTREMITIES

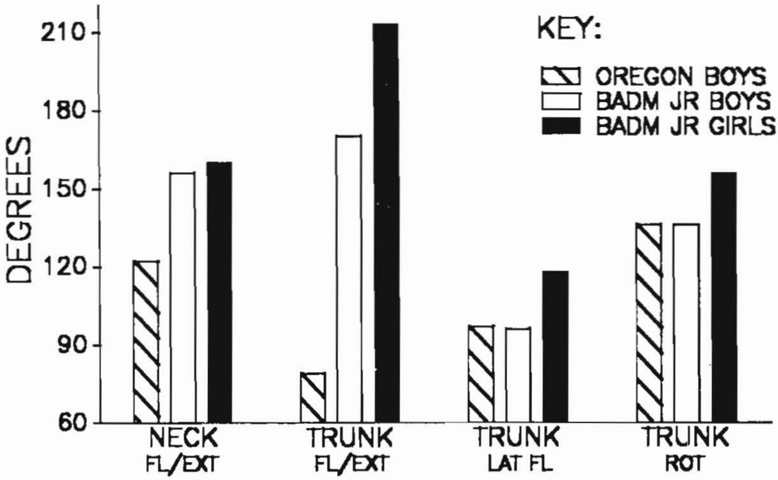

FIGURE 3. FLEXIBILITY – AXIAL SKELETON

## *Discussion*

In the absence of comparable data from other badminton players, the results of the physiological measures were compared with a group of 12 male Junior National Soccer Team players, whose average age was 16 years, and who had been tested on the same equipment in 1986.

No norms were available for the seven-site skinfolds measure. It was not surprising that the body composition of the badminton girls indicated more fat tissue than for the badminton boys.

Maximal aerobic power: the mean value of the soccer players when corrected for body mass was 57.25 $ml.kg.min^{-1}$, which was only slightly higher than the male badminton players' mean of 56.34 $ml.kg.min^{-1}$. Apparently, the two groups of players are similar in aerobic power.

Anaerobic capacity: the mean exercise tolerance time for the male soccer players was 47.9 s and produced a mean blood lactate of 9.4 mMol/1. By comparison, the mean exercise tolerance time for the male badminton players was only 28.8 s which produced a mean blood lactate of 9.49 mMol/1. Both groups ran at 16.1 km/hr (10 mi/hr) at a 16% grade. These results show that the badminton players fell far short of the soccer players in anaerobic capacity. Although it is noted that the badminton players were an average of 1.5 years younger, their anaerobic fitness needs improvement.

Strength: the means for the right leg were higher than those for the left leg. Since 15 of the subjects were right-handed players and therefore go to the net and play most strokes with the right leg forward, it would be logical that the right leg is stronger than the left. The means of males for all strength measures, including those corrected for body mass were higher than those for the females. The apparent anomaly of applying more force at the higher speeds for each measure can be explained as the impact torque, not peak torque, that is being measured on the Cybex.

Flexibility: a comparison of flexibility measures of the badminton juniors with a group of 16-year-old boys in Oregon (Fig. 1, 2, and 3) showed that the badminton boys were superior or comparable to the Oregon boys in all of the tests except shoulder flexion/extension. The scores of the badminton junior girls exceeded those of the badminton junior boys in all tests except radio-ulnar supination/pronation, abduction/adduction of the wrist, and left ankle inversion/eversion.

## *Conclusions*

Generally, the 16 players performed well when compared with other individuals in all categories except anaerobic capacity. The present study is significant through the establishment of a data base to compare with later testing of the same group of athletes, and other young badminton players. The results provided physiological and flexibility values upon which individual training programs are being developed.

## *References*

Astrand, P.O. and Rodahl, K. (1970). Energy cost of various activities. *Textbook of Work Physiology*, ed. P.O. Astrand and K. Rodahl.

Coad, D., Rasmussen, B., and Mikkelsen, F. (1979). Physical demands of recreational badminton. In: *Science in*

*Racquet Sports*, ed. J. terauds. Del mar, CA, Academic Publishers.

Gilliland, B. (1987). *Training schedule for elite badminton players.* Ottawa: Canadian Badminton Association.

Leighton, J.R. (1966). The Leighton flexometer and flexibility test. *J. Asso. for Phys. and Mental Rehab.* 20:No. 3:86.

MacDougall, J.D., Wenger, H.A., Green, H.J. (1982). *Physiological testing of the elite athlete.* Ottawa: Canadian Association of Sciences.

Margaria, R., Cenetelli, P. Aghemo, P. and Sassi, G. (1963). Energy cost of running. *J. Appl. Physiol.* 18:367.

Mikkelsen, F. (1979) Physical demands and muscle adaptation in elite badminton players. In: *Science in racquet sports*, ed. J. Terauds. Del Mar, CA: Academic Publishers.

Reed, A. (1981). *A manual on the training of badminton players.* Ottawa: Canadian Badminton Association.

Saltin, B., Astrand, P.O. (1967). Maximal oxygen uptake in athletes. *J. Appl. Physiol.* 23:353.