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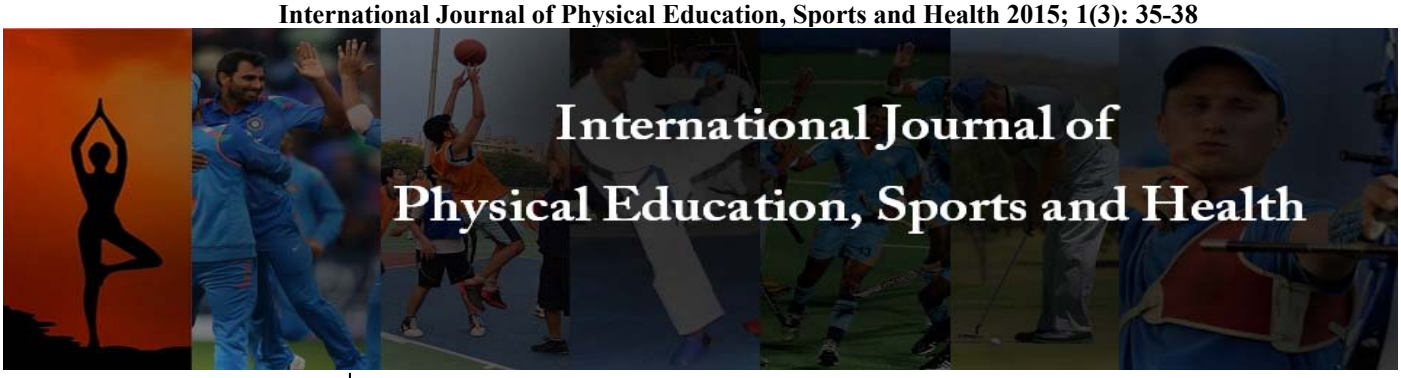

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Jayasudha Katralli
Assistant Professor, Dept. of Physiology, SSIMSRC, Jnanashankara, Nh4 Bypass, Davangere, Karnataka, India.

Veeresh Itagi
Assistant Professor, SSIMSRC, Jnanashankara, NH4 Bypass, Davangere, Karnataka, India.

Shivaprasad S Goudar
Professor, Department of Physiology, Jawaharlal Nehru Medical College, Belgaum, Karnataka, India.

Correspondence:
Jayasudha Katralli
Assistant Professor,
Dept. of Physiology,
SSIMSRC, Jnanashankara, Nh4 Bypass, Davangere, Karnataka, India.

Assessment of Aerobic Capacity and Muscle Strength in Indian Judokas

Jayasudha Katralli, Veeresh Itagi, Shivaprasad S Goudar

Abstract
Olympic judo is dynamic, demanding sport, requiring a high degree of physical conditioning and strength in order to be successful. VO_{2max} is a person's capacity to sustain high-intensity exercise for longer than 4 to 5 minutes. Maximal muscle strength is peak strength value under static conditions. Aerobic capacity and muscular strength play an important role in performance. This cross sectional study was conducted on 31 judo players. Height, weight and BMI calculated. Aerobic capacity VO_{2max} was determined by Bruce protocol using treadmill. Muscular strength by 1 repetition maximum (1RM) Bench press and bench squat. Students unpaired't' test used for analysis. VO_{2max} was higher for Judo B group (66.7 ± 10.13ml/kg/min). Group B players showed high Muscular strength scores. Long term training can have an effect on parameters of physical fitness as aerobic capacity and muscular strength. The present findings used by coaches and trainers as a tool to optimize the training programs for the attainment of the best performance of the judoka.

Keywords: Muscular strength, 1 repetition maximum, Aerobic capacity, VO_{2max}

1. Introduction
Olympic judo is a dynamic, physically demanding sport, requiring a high degree of physical conditioning and strength in order to be successful and offset fatigue. Many authorities characterize sport judo as an explosive power sport, requiring tremendous reserves of anaerobic power and capacity, yet operating within a well-developed aerobic system [1, 2] .Competitive judo can also be described as a combative, high intensity sport in which the athlete attempts to throw the opponent onto his back or to control him during groundwork combat. Both attempts depend on specific techniques and tactical skills with the support of good physical fitness [3].

The oppositional relationship, which predominates in a judo session, is a dynamic, continuously changing environment whose nature forces high demands on athletes, the technical-tactical routines they apply in a combat must be perfected to the maximum, they must possess ability to quickly reorganize the motor programmes, and to constantly and instantly create new defensive, or counter-attacking courses of action [4].

In Judo movements are powerful, delivered in a short period of time, usually against the force of the opponent [5]. It is a type of sport activity that require the alternative metabolic involvement of aerobic and anaerobic pathways [1, 6]. A judo combat is characterized by the presence of brief intense muscular actions (15 to 30-second) in which the anaerobic system is primarily involved. On the other hand, the entire duration of a judo combat (more than 5 minutes) implies the involvement of the aerobic system, especially toward the end of the combat [1]. Recently, International Judo Federation [7]. has introduced a rule (golden score) consisting of the possibility of allowing a five minute extra-time in case no final verdict is achieved at the end of the normal 5 minute combat. Stillmore, the need for an adequate aerobic conditioning in this sport is further justified by the fact that each judoka can be involved in a different number of combats within the same competition day. The VO_{2max} estimation is an important component of cardiovascular endurance which is useful in determining a person's capacity to sustain high-intensity exercise for longer than 4 to 5 minutes [8].

The significance of maximal muscle strength development for athletic performance improvement in most of the sports disciplines is generally accepted. During training and competition, the human body uptakes energy for the activities, depending on their intensity and duration. Research has shown that the energy for muscle activity in judo is predominantly derived from anaerobic sources and suggests that of adenosine triphosphate (ATP)

replenishment comes from creatine phosphate (CP) in 90 %, and lactate glycolytic pathway up to 10 % [9]. It is also well documented that muscle strength represents one of the most important motor abilities in Judo as a sport [7, 9]. Maximal muscle strength is usually defined as a peak strength value under static conditions and represents the ability of muscle or muscle group to overcome the loading [10].

The evaluation of physiological characteristics is an important part of the training process because it gives information about the variables that need to be improved and about the effectiveness of a given training program. However, judo athlete's evaluation is usually made in laboratory setting [1]. The energetic requirements of a competitive match need to be analysed to provide yardstick for developing athletes and to improve the monitoring of training. The measurement of maximal static muscle torque and maximal power output yields valuable information that can be extremely useful in judo training [11]. Hence this study was undertaken to assess the aerobic capacity and muscular strength in Indian judo players.

2. Methodology

This cross sectional study was conducted in Jawaharlal Nehru Medical College, Belgaum. The sports participants were divided into two groups depending on number of years of judo training. **Judo A** group consisted of players **≤ 5 years** of Judo training and **Judo B** group consisted of the senior players with **>5 years** of training. Using universal sampling data was collected from 31 judo players. All the players participated in consistent judo training.

2.1 Inclusion criteria

All the judo players practicing regularly for a minimum period of 3 years and who were in the age group of 18-25yrs.

2.2 Exclusion criteria

1. Subjects with respiratory, neuromuscular, cardiac, endocrine disorders.
2. Players with history of taking drugs, medication, or supplements.

The study was approved by the Ethical and Research Committee of the institution. After finding the suitability as per selection criteria, the players were selected for the study and briefed about the nature of the study and written informed consent was obtained from them. Descriptive data of the participant's age, medical history, training schedule regarding number of years of judo practice, number of days in a week, number of hours per day and dietary history were obtained by interviewing the participants.

Several laboratory tests have been used to assess effort capacity. But, the best tests are those which will give similar effort responses as those ones observed in a competition. When direct methods are not feasible variety of maximal and submaximal exercise tests are used to estimate VO_{2max}. Maximum effort testing requires subjects to exercise to highest possible, begins at low work load and increases according to specific protocol used until volitional fatigue occurs. To assess aerobic capacity test was done on motor driven treadmill (Model-Fitness world 3000, manufacturers-Square cut, Belgaum) to calculate the most accepted criterion-VO_{2max} (maximum oxygen uptake) by using Bruce protocol which is commonly used treadmill exercise stress test used to estimate cardiovascular fitness.

Exercise was performed on a treadmill. The test starts at 2.74 km/hr (1.7 mph) and at a gradient (or incline) of 10%. At three minute intervals the incline of the treadmill increases by 2%, and the speed increases according to the standard protocol. Subject was told to do maximum effort and inform at exhaustion. The test score was the time taken on the test, in minutes. This is converted to an estimated VO_{2max} score using following formulas, where the value "T" is the total time completed (expressed in minutes and fractions of a minute e.g. 9 minutes 15 seconds = 9.25 minutes).

VO_{2max} (ml / kg / min) = $14.76 - (1.379 \times T) + (0.451 \times T^2) - (0.012 \times T^3)$

Muscular strength was measured using one repetition maximum (1RM) bench press and bench squat (Sky health, Mumbai) performed using free weights. **Benchpress:** Participant assumed supine position on the bench. Two assistants placed the weight lifting bar with weights in his hands and across the chest. The participant extended his arms pressing the bar to an elbow straight position. Bar is removed. After completion of the first trial successfully, successive trials with an added weights were tried. The best score of the three trials was recorded and then divided by his body weight which gave the score of the test. **Bench squat:** Two assistants placed the bar on the shoulders (across trapezius) of the participant with weights adjusted as he stands at the edge of the bench. With the feet apart and a firm grasp of hands on bar he lowered to an erect sitting position on the bench. This was achieved when the greater trochanter was lowered to the same level as the knee. Then, without rocking back and forth, the participant returned to the standing position then removed weight. Readjust weight for successive trails. The best score of the three trials was recorded and then divided by his body weight which gave the score of the test [12, 13].

2.3 Statistical analysis

Statistical analysis involved quantitative variables summarized through mean and standard deviation. Difference between mean of the two groups was tested using Students unpaired't' test, where significance of the p value was < 0.05.

3. Results and Discussion

Out of 31 Judo players, based on years of judo training 20 players and were included in JUDO A group and 11 players in JUDO B group. We had 14 Males and 6 female players in group A and 5 males and 6 female players in judo B group. Mean height (cms) and weight (kg) of players in judo a group (166.8 ±7.09 and 61.8 ± 8.53) respectively, and in judo B it was (158.5 ± 15.34 and 59.7 ± 11.53). The difference was not statistically significant. Mean BMI of A and B groups were 22.4 ± 1.90 & 24.1 ± 4.88 respectively.

Table 1 shows the comparison of cardiorespiratory fitness among the two player groups. Mean distance covered on the treadmill and Total test time on treadmill was high for Judo B group compared to Judo A and the difference was statistically significant ($p<0.05$). VO_{2max} – maximum oxygen uptake mean was higher for Judo B players (seniors) but was not statistically significant. One repetition maximum (1 RM) using Bench press and Bench squat, mean weight pushed and mean score in both the tests for muscular strength was observed to be similar in the two player groups.(Table 2)

Cardiorespiratory endurance is the ability to perform sustained dynamic activity using large muscle groups or body's ability to deliver oxygen effectively to the working muscles to perform physical activity, or It is the ability of the circulatory and respiratory systems to adjust to and recover from the effects of exercise or work. This is the most important component of health fitness concerned with the aerobic efficiency of the body.

3.1 Table 1: showing cardiorespiratory fitness of judo players

Parameters	JUDO A(≤ 5 yrs)	JUDO B(>5yrs)	p Value
Distance covered Km/hr	2.8 ± 0.70	3.4 ± 0.80	0.034*
Total test time on treadmill (min)	25 ± 4.99	30.2 ± 5.51	0.013*
VO_{2max} (ml/kg/min)	58.6 ± 13.48	66.7 ± 10.13	0.068

(*) p value significance = < 0.05

3.2 Table 2: Muscular strength comparison between Judo A and B groups

		JUDO A(≤ 5 yrs)	JUDO B(> 5yrs)	p Value
Bench press	weight pushed	61.7 ± 18.75	65.1 ± 21.04	0.653
	Score	0.94 ± 0.36	1.02 ± 0.49	0.641
Bench squat	weight pushed	112.2 ± 30.07	118.5 ± 24.96	0.557
	Score	1.82 ± 0.48	2.04 ± 0.53	0.265

(*) p value significance = < 0.05

Aerobic exercises are of light to vigorous intensity physical activity that requires more oxygen than sedentary behavior and thus promotes cardiovascular fitness and other health benefits (e.g., jumping rope, biking, swimming, running; playing soccer, basketball, or volleyball). Individual's aerobic fitness or aerobic capacity is determined by a large number of interrelated factors. Primarily it is determined by the individual's capacity to utilize oxygen. A person's maximum capacity to use oxygen is referred to as that person's VO_{2max}. It is the criterion measure of cardiorespiratory fitness. Which measures amount of oxygen consumed per kilogram of body weight per minute of exercise. Maximum oxygen uptake is the product of the maximal cardiac output and arterial venous oxygen difference. In the different methods cardiovascular system is put under stress by different means and cardiovascular response was observed during and after stress is over. Efficiency of circulation lies in giving prompt response to any sudden stress and then returning to normal limits as soon as stress is over. This forms the basis of cardiac efficiency test. The analysis of judo competitive actions shows that all ducts of energetic functions are used. Considering the contest duration and the number of contests during a tournament, aerobic capacity is also important in terms of better use of the judoka's system and the prompt recuperation process [14].

In our study results of treadmill test by using Bruce protocol for calculation of VO_{2max} was higher for Judo B group (66.7 ± 10.13). This is in consistent with previous studies on elite American Judoist had 53.2 ml/kg/min, elite Canadian Judoist had 59.2 ml/kg/min, elite Australian Judoist had 53.2 ml/kg/min and Turkish Judoist had 43.25 ml/kg/min [3, 1, 15].

In our study we had a higher but, insignificant value of VO_{2max} for Judo B group, similar to some authors who also did not find significant differences in VO_{2max} between elite and non-elite judo players [16, 17]. Studies have found that judo players with a higher VO_{2max} presented a faster Creatine Phosphate re-synthesis compared with judo players with a lower VO_{2max}. It has been suggested that judo players with a higher VO_{2max} would have an advantage in a period of combat with maximal duration (5-min) because the same absolute supramaximum effort would represent a lower relative intensity compared to an athlete with a lower VO_{2max}.

Research indicates that aerobic training can increase VO_{2max} 15-20 % with training. The biochemical and metabolic adaptations that occur with endurance training are an increase in glycolytic enzymes (LDH, PDH, PFK), beta oxidation enzymes (acyl carnitine transferase), as well as increases in citrate synthetase in the TCA cycle. The primary benefit of these physiological changes is due to a greater use of fatty acids via beta oxidation for metabolic energy, thus reducing the demand for glycogen via glycolysis. This in turn will provide a "glycogen sparring" effect, therefore prolonging the time it takes to fatigue during strenuous exercise. Applications of aerobic conditioning to judo involves a greater recovery from anaerobic work [18].

A study done on elite Brazilian judo team shows a positive influence of a higher VO_{2max} on intermittent exercise performance is partially confirmed by the positive correlation between this variable and the number of throws in the Special Judo Fitness Test [19]. The greatest benefit of aerobic training is the judo player's ability to operate at a high percent of their individual aerobic capacity. Research has indicated that trained aerobic individuals can work at 75-85% of their aerobic power before experiencing fatigue. Judo performance does require a good aerobic base or aerobic working capacity, and this can be developed through the nature of a typical competition practice.

Maximal muscle strength is usually defined as a peak strength value under static conditions. Muscle Strength depends on the following factors: the size of muscle cross-section – relative strength (1 cm^2 of a cross-section may develop strength of 7-10kg), the number of muscular motor units, proportion of slow twitch (ST) muscle fibres to fast twitch (FT) fibres; the more FT fibers the greater strength can be developed by a given muscle; proportions of bone levers, energy release from phosphocreatine decomposition, age and gender. The increase in maximal muscle strength is mediated by two mechanisms, namely: An increase in muscle fibres and increase in the number of active motor units, as a result of changes in movement control by the nerves during the initial training period, an increase in strength developed during maximal contractions is mainly connected with the stimulation of a bigger number of motor units. After about two weeks, an increase in strength occurs, mainly due to hypertrophy [20].

The outcome in this study for bench press and squat score were similar among both the judo groups. This finding was opposite to the previous study done in Serbia [21]. These finding suggest that the players of both groups had adequate muscle strengthening and conditioning programmes in their

training schedule. The effects of the training with load mainly relate to adaptation of contractile structures, which increase muscular strength. Fast adaptation of the nervous system explains fast and significant advance in muscular strength during early phases of training followed by increasing of strength and muscular hypertrophy in later phases [22, 23]. The increase in maximal muscle strength is mediated by two mechanisms, firstly an increase in muscle fibers, secondly an increase in the number of active motor units as a result of changes in movement control by the nerves; during the initial training period, an increase in strength developed during maximal contractions is mainly connected with the stimulation of a bigger number of motor units. The extremely important role of strength is manifested in the first phase (kuzushi) of disbalancing the opponent, then in the second phase (tsukuri) when the body contact is established with uke and when a squat or a semi-squat is performed, as well as in the third phase of a throw performance (kake), when the opponent's foot is swept, or when he/she is lifted up by hips and simultaneously drawn down to the mat by the tori's strong arms [4]. An adequate planning of muscle strength development requires the knowledge of the principles, methods or physiological mechanisms involved in muscle strength regulation and also of the relations between the number of repetitions performed during exercises and the developed fitness of the muscular system. The basic training goal is to develop is body adaptation to increasing loads.

4. Conclusion

Training shows effects on aerobic capacity and muscle strength. Judo coaches choose training methods and tools according to each competitor's weight category and fighting style. In order to make good training protocol it is also necessary to understand the energy pathways during a short term judo fight of high intensity. In training process, it is necessary to develop sport specific abilities, which are going to affect the sport result and the present findings may be successfully used by coaches and trainers as a tool to optimize the training programs for the attainment of the best performance of the judoka.

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