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Original Research Article

Effect of Eight Week Physical Training on Isokinetic Strength and Aerobic Capacity in Indian NCC Personnel

Devashish Raturi[1], Shyamal Koley[*1], Priyanka Rodge[1] and Shweta Shenoy[2]

[1]*Department of Sports Medicine and Physiotherapy, Guru Nanak Dev University, Amritsar-143005, Punjab, India.*
[2]*Centre for Physiotherapy and Rehabilitation Sciences, Jamia Milia Islamia, A Central University, Jamia Nagar, New Delhi – 110025, India.*

*Correspondence Info:

Prof. (Dr.) Shyamal Koley,
Head & Dean,
Department of Sports Medicine and Physiotherapy,
Guru Nanak Dev University, Amritsar – 143005, Punjab, India.
E-mail: drkoley@yahoo.co.uk

Abstract

Objectives: The objectives of the present study were to estimate the physical fitness parameters such as Isokinetic strength and aerobic capacity of 80 randomly selected Indian NCC cadets aged 15-25 years and to search their correlations with selected physical fitness variables studied.

Methods: To serve these purposes, three anthropometric variables such as, height, weight, BMI, five Isokinetic strength measurements (both in extension and flexion), such as peak torque, peak angle, cycle time and maximum power of knee, ratio of peak torque in flexion and extension, and six aerobic capacity measurements, such as, VO_2 max, VCO_2, respiratory exchange ratio, ventilatory equivalent, maximum heart rate and time of treadmill running were measured on all the subjects.

Results: Peak torque and maximum power flexion and extension were increased significantly ($p<0.001$) in the Indian NCC cadets before and after eight weeks training. The ratio of the extension and flexion peak torque were also increased significantly ($p<0.05$). The endurance was improved significantly with VO_2 max ($p<0.001$) and time of running ($p<0.001$) among them. Significant improvement was observed in respiratory exchange ratio ($p<0.001$) and ventilatory equivalent ($p<0.01$).

Conclusion: It was found that the strength and endurance had significantly advantageous changes after eight weeks of training (in NCC camp). Hence it may be concluded from the present study that the NCC training induces beneficial and significant improvement in the physical fitness components of their cadets.

Keywords: Aerobic capacity, VO_2 max, Isokinetic strength, Indian NCC cadets.

1. Introduction

The Indian national cadet corps (NCC) was established under the NCC Act, 1948. The NCC's presence presently extends to 633 districts of the country covering 15,954 institutions. The training in NCC comprises the following important aspects; institutional training, camp training, adventure training, social service and community development activities and youth exchange programme. The NCC, the reserve defence forces of India, recruit and train cadets enrolled through voluntary participation of adolescents from schools and colleges throughout the country. Training involves routine participation in drills, exercises, sports and other recreational activities like mountaineering and tracking[1,2].

Physical fitness is the ability to perform moderate to vigorous levels of physical activity without excessive fatigue and the capability of maintaining such ability throughout life. Health related athletic ability components of physical fitness include: cardio respiratory fitness, body composition, flexibility, muscular strength and muscular endurance [3]. The physical Fitness standards required at the end of basic training in military organizations generally include measures of muscular strength and endurance and aerobic endurance. [4].

Physical training can be described in terms of its outcome and process. Outcomes of the training are anatomical, physiological, biochemical and functional changes specific to the sport discipline, while the training process is characterized by the systematic repetition of physical exercises [5].

The maximal (VO_2 max) and sub maximal (lactate and ventilatory thresholds) parameters of aerobic fitness are commonly considered as accurate measures of aerobic power and capacity [6]. There is a general unanimity that VO_2 max is limited mostly by the ability of the cardiovascular system to transport oxygen to the active muscles, and the lactate threshold by the peripheral ability to utilize oxygen (e.g. mitochondrial enzyme activity) [7,8]. Therefore, the

assessment of these variables using appropriate protocols could provide useful information to coaches about the effect of aerobic training on central and peripheral factors.

Isokinetic strength testing is the gold standard to evaluate the peak torque and angles at which these torque are applied maximum. After a basic training which incorporated both endurance and strength regimes there are strong evidences on improvement of knee strength. Isokinetic knee extension and flexion dynamometry are highly reliable (ICC = 0.96–0.97 and ICC = 0.93–0.98, respectively) and valid measures of quadriceps and hamstring muscle performance that identify personnel at risk for overuse knee joint injury, and significantly predict hopping, leaping, and jumping ability as well as straight-line and agility sprint performance[9,10].

Literature related to the estimate of isokinetic strength and endurance in Indian NCC cadets are scanty, thus the present study was planned with the objectives to determine changes in maximal oxygen uptake (VO_2 max) and other endurance parameters (ventilatory equivalent, respiratory exchange ratio, time of running), and to determine changes in knee Isokinetic (flexion/extension) strength, maximum power and ratio of the peak torque flexion and extension before and after training of eight weeks in Indian NCC cadets.

2. Material and Method

2.1 Study Participants

For the present study, eighty Indian NCC cadets with age range 15-25 (mean age 20.00 years ±2.90) were enrolled from different institutions of Amritsar city, Punjab, India, having mean stature 171.2 ± 7.33 cm, mean body mass 62.9 kg ±10 and mean body mass index 21.4 kg/m^2 ± 2.62, were randomly selected to participate voluntarily. All participants got the NCC basic training and attended the various camps organized by the corps. After an informed written consent, the demographic information, life style pattern and history regarding medication/surgery was noted down on pre-designed questionnaire. In the initial fitness testing, all 80 samples were tested for their endurance and Isokinetic strength. During the post training assessment, 6 samples were dropped because of their non availability. Hence a total of 74 participants were finally tested and analyzed before and after the training. The study was approved by the institutional ethics committee.

2.1.1 The inclusion criteria for the subjects were as follows:

1. Healthy cadets who are currently enrolled in the NCC and are in the different institutions of Punjab i.e. schools, colleges.
2. Only male cadets were considered for the study.

2.1.2 The exclusion criteria for the subjects were as follows:

1. Recent injury to lower limb and Musculoskeletal disorders.
2. Cardiac or respiratory disorders.
3. Metabolic disorder.
4. Systemic illness.

2.2 Anthropometric Measurements

Three anthropometric variables, such as height, weight and body mass index were measured using the techniques provided by Lohmann *et al* [11] and were measured in triplicate with the median value used as the criterion.

The height was recorded during inspiration using a stadiometer (Holtain Ltd., Crymych, and Dyfed, UK) to the nearest 0.1 cm, and weight was measured by digital standing scales (Model DS-410, Seiko, Tokyo, Japan) to the nearest 0.1 kg. BMI was then calculated using the formula weight (kg)/height^2 $(m)^2$.

2.3 VO_2 max/Cardio Respiratory Fitness

To assess the maximum aerobic capacity (VO_2 max), a portable gas analyzer metamax 3B (Cortex, Germany) integrated with a motorized treadmill h/p/cosmos mercury [cos 10198-01] (Germany) were used. Prior to commencing the test, each participant was told about the incremental exercise protocol, continuous electronic heart rate monitoring throughout the test. Participants were instructed to drink plenty of fluids and restrict themselves from strenuous exercises 24 hours prior to testing and not to consume product like alcohol, caffeine, tobacco 3 hours before the test. The cadets performed an incremental test to volitional exhaustion in accordance with the Bruce protocol on a motorized treadmill [12]. Each cadet was equipped with a heart rate monitor (polar T34 transmitter, Kempele, Finland) and a mask (Hans Rudolph V, Shawnee, Kansas, USA) before entering the test treadmill [13]. The test started with an initial warm up period of three minutes at a speed of one mile/hour. Following the warm up stage, speed and grade for each cadet increased every three minutes at a speed of one mile/hour. Following the warm up stage, speed and grade for each participant increased every three minutes in accordance with the above said protocol till volitional exhaustion. Maximum oxygen uptake was measured using an open circuit breath by breath automated pre calibrated gas analysis system directly transferred to computer using cortex Metasoft (version, 3.9) software. VO_2 max was determined based on a plateau in VO_2 consumption or participant reaching volitional fatigue [14]. Peak heart rate was also recorded at the end of the test. Both volumes as well as pressure calibration of gas were routinely performed. The measurement was conducted at a constant ambient temperature of 19-22 degrees, 1-3 hours after light meal. The factors for VO_2 max assessment were, first the respiratory exchange ratio should come below 1, then, there should be a plateau which was attained during the maximal incremental protocol, and finally, the maximum heart rate should lie not more than 220- age [17].

2.3.1 Isokinetic Hamstring and Quadriceps Strength /Isokinetic Dynamometer

Isokinetic knee extensor and flexor testing was conducted at 60/sec in cadets. The cadet first completed a dynamic warm up session that lasted 5 minutes. They were then positioned in the chair of the device with appropriate

torso, pelvis and thigh straps placed according to the manufacturer's protocol.

The lever arm of the dynamometer was aligned with the lateral condyle of the knee, with the knee flexed at 90 degrees. The chair was adjusted for each cadet as required to ensure proper positioning. The range of motion during the test was fixed from 90 to 0 degree. Gravitational factors were calculated by the dynamometer and automatically compensated during the tests. The athletes performed three to four sub maximal trials to become familiar with the machine and test velocity. A total of 7 repetitions and 3 sets were completed and the highest peak torque value was used for analyses. Mean peak torque values (in Newton-meter) were normalized for body weight in kilograms. Verbal encouragement was given throughout the tests, because the athletes were told to kick as hard and as fast as possible, but no visual feedback was available.

2.4 Statistical Analysis

Standard descriptive statistics (mean ± standard deviation) were determined for directly measured variable. Paired t-test was applied to compare the variables before and after the training of the subjects. Pearson's correlation coefficients were applied to establish the relationships among the variables measured. Data were analyses using SPSS (Statistical Package for Social Science) version 20.0. A 5% level of probability was used to indicate statistical significance.

3. Results

Table 1 showed the descriptive statistics of isokinetic knee strength (flexion /extension) before and after training of the Indian NCC cadets. In extension, significant increase was found in the peak torque ($p<0.001$) and maximum power ($p<0.001$), and significant decrease in time to peak torque ($p<0.001$) and cycle time ($p<0.042$) before and after the training of the NCC cadets. Whereas in flexion, significant increase were found in peak torque ($p< 0.001$), peak angle ($p<0.025$) and maximum power ($p<0.001$), and significant decrease in time to peak torque ($p <0.001$). So for the ratio of peak torque and flexion was concerned, significant decrease was also reported ($p<0.013$).

Descriptive statistics of endurance (VO_2 max in litres and ml/kg/min) before and after training of the Indian NCC cadets were shown in table 2. Significant increase were noted in VO_2 max ($p<0.001$), ventilatory equivalent ratio ($p<0.007$), respiratory exchange ratio ($p<0.001$) and time of treadmill running ($p<0.001$).

Table 3 showed the correlation coefficients of selected strength variables with endurance in pre and post training. Peak torque extension had a significant positive correlation ($p<0.001$) with peak torque flexion both pre and post training. Whereas, peak angle extension had a significant positive correlation ($p< 0.05$) with peak torque extension in post training. Time to peak torque extension and flexion had a significant negative correlation ($p<0.05$ - 0.01) with peak torque extension both in pre and post training among the NCC cadets. Maximum power extension had a significant positive correlations ($p<0.001$) with peak torque flexion and extension both in pre and post training group. Peak torque flexion had a significant positive correlation ($p<0.001$) with peak torque extension both pre and post training. Time to peak torque flexion had a significant negative correlation ($p<0.01$) with peak torque extension and flexion in post training data. Cycle time flexion had a significant positive correlation ($p<0.05$) with VO_2 max in pre training.

Table 1: Descriptive statistics of Isokinetic knee strength (flexion /extension) before and after training of cadets

Variables	Pre-training	Post-training	t-value	df	Mean difference	95% Confidence Interval of the difference		Sig
	Mean±SEM	Mean±SEM				Lower	Upper	
	iso-kinetic dynamometry							
Peak torque (extension)	158.53 ±5.46	225.2±6.47	-7.874	122.557	-66.672	-83.434	-49.910	**0.001**
Peak angle (extension)	65.12 ±1.63	63.6±0.89	0.822	97.451	1.523	-2.153	5.200	0.412
Time to peak torque (extension)	0.76 ±0.03	0.62±0.02	4.789	100.644	0.147	0.086	0.207	**0.001**
Cycle time (extension)	2.29 ±0.05	2.17±0.03	2.052	96.726	0.114	0.004	0.224	**0.042**
Maximum power (extension)	74.14 ±3.29	110.08±3.94	-7.000	122.157	-35.938	-46.100	-25.775	**0.001**
Peak torque (flexion)	83.45 ±3.08	121.48±3.78	-7.805	120.998	-38.031	-47.678	-28.384	**0.001**
Peak angle (flexion)	69.22 ±4.22	79.44±1.57	-2.272	80.040	-10.228	-19.187	-1.268	**0.025**
Time to peak torque (flexion)	0.75 ±0.03	0.53±0.02	5.635	105.623	0.215	0.139	0.290	**0.001**
Cycle time (flexion)	2.44 ±0.06	2.31±0.05	1.643	119.969	0.128	-0.026	0.283	0.103
Maximum power (flexion	43.52 ±2.31	72.09±2.64	-8.159	123.794	-28.578	-35.511	-21.645	**0.001**
Ratioof peak torque in ext. and flex.	0.52 ±0.01	0.56±0.01	-2.533	125.791	-0.041	-0.073	-0.009	**0.013**

The knee extension to flexion ratio had a significant positive correlation ($p<0.01$) with peak torque flexion both in pre and post training. The VO_2 / litres had a significant positive correlation ($p<0.01$) with peak torque extension and flexion and VO_2 /ml/kg/min both in pre and post training. Time of running had a significant positive correlation with peak torque extension ($p< 0.05$) in pre training and VO_2 max both in pre and post training ($p< 0.001$). Respiratory exchange ratio had a significant positive correlation with VO_2 max/ml/kg/min in pre ($p<0.01$) and V'E had a significant positive correlation ($p<0.001$) with VO_2 max/ml/kg/min both in pre and post training in the NCC cadets.

5. Discussion

Training load and training intensity are two important factors to success in any training protocol. The assessment of internal training load is particularly relevant in team sports, where the external load is often the same for each member of the team because of the extensive use of group exercises [15]. On the other hand, to maintain the training intensity during exercise is also important (with some variation even within the same individual) [16]. In the present study, after the training, it was observed that the isokinetic knee flexion and extension showed extremely significant improvements. Improved strength corresponds to improved blood flow, mitochondrial activity, motor unit activation and synchronization, better enzymatic activation, capillary density etc [17]. The component of plyometrics, stretch shortening drills might have improved the muscular activity and hence increased peak torque, time to peak torque also significantly reduced[18].

Table 2: Descriptive statistics of endurance (VO_2 max) before and after training of the Indian NCC cadets

variables	Pre-training	Post-training	t-value	df	Mean difference	95% Confidence Interval of the difference		Sig
	Mean	Mean				Lower	Upper	
	Endurance/Aerobic Capacity							
VO_2 max (litres)	2.53 ±0.06	3.00±0.05	-5.739	120.232	-0.470	-0.632	-0.308	**0.001**
VCO_2 (litres)	2.68 ±0.10	2.47±0.10	1.471	125.689	0.204	-0.070	0.478	0.144
Ventilatory equivalent	93.97 ±2.65	103.56±2.29	-2.735	123.417	-9.589	-16.528	-2.650	**0.007**
Respiratory exchange ratio	1.03 ±0.03	0.82±0.03	5.309	125.369	0.214	0.134	0.294	**0.001**
Heart rate (beats /min)	189.19 ±1.69	190.52±1.07	-0.666	106.485	-1.328	-5.284	2.627	0.507
VO_2 (ml/kg/min)	41.00±1.01	50.50±0.85	-7.184	122.348	-9.500	-12.118	-6.882	**0.001**
Time (min)	10.75±0.18	13.09±0.18	-9.142	125.961	-2.345	-2.852	-1.837	**0.001**

The ratio of peak torque of extensors and flexors of knee also showed highly significant outcomes. However, the cycle time of extension movement of knee showed significant changes pre and post training ($p<0.05$). Because of the effect of the increased quadriceps strength the movement of extension was completed quickly after training. In the peak angle of flexion movement, significant changes were observed ($p<0.05$). Maximum power considerably improved both in flexors and extensors of knee of the concerned cadet.

Baquet *et al* [19] did a meta-analysis on 51 studies out of which 22 were finally fit into criteria and were retained. They analyzed the characteristics of each training protocol and the changes in endurance and finally concluded that a mean changes of 5-6% of peak VO_2 in adolescents. The findings of the present study were similar to the above said study.

Table 3: Correlation coefficients of selected strength variables with endurance in pre and post training of the Indian NCC cadets

Variables	Pre- training						Post- training					
	PTE		PTF		VO_2/Kg		PTE		PTF		VO_2/Kg	
	r	p	r	p	r	p	r	P	r	P	r	p
Peak torque ext			0.796	**0.001**	0.112	0.377	1.000		.758	**0.001**	0.149	0.239
Peak angle	-0.086	0.498	-0.018	0.891	-0.040	0.756	0.260	**0.038**	0.129	0.311	-0.091	0.474
Time to peak torque	-0.325	**0.009**	-0.369	**0.003**	-0.045	0.724	-0.302	**0.015**	-0.283	**0.023**	-0.099	0.439
Cycle time	-0.015	0.905	0.059	0.642	0.258	**0.040**	-0.162	0.200	-0.053	0.679	-0.069	0.586
Max power	0.890	**0.000**	0.727	**0.001**	0.143	0.258	0.788	**0.001**	0.690	**0.001**	0.139	0.274
Peak torque flex	0.796	**0.000**	-	-	0.183	0.148	0.758	**0.001**	1.000	-	0.013	0.920
Peak angle	0.045	0.726	0.135	0.286	0.075	0.554	0.065	0.610	0.086	0.498	0.057	0.656
Time to peak torque	-0.111	0.383	-0.179	0.157	-0.232	0.065	-0.368	**0.003**	-0.330	**0.008**	-0.192	0.129
Cycle time	-0.165	0.193	-0.078	0.540	-0.049	0.702	-0.175	0.167	-0.180	0.154	-0.154	0.224
Max power	0.689	**0.000**	0.775	**0.001**	0.308	**0.013**	0.642	**0.001**	0.868	**0.001**	-0.041	0.746
Ratio	-0.231	0.066	0.334	**0.007**	0.189	0.135	-0.180	0.154	0.343	**0.005**	0.027	0.832
Vo2/ litres	0.285	**0.023**	0.249	**0.047**	0.624	**0.001**	0.436	**0.001**	0.253	**0.044**	0.542	**0.001**
Vco2	0.276	**0.027**	0.259	**0.039**	0.583	**0.001**	0.258	**0.040**	0.118	0.352	0.163	0.199
V'E	0.230	0.068	0.197	0.118	0.531	**0.001**	0.148	0.242	0.072	0.571	0.427	**0.001**
RER	0.122	0.338	0.188	0.136	0.333	**0.007**	0.075	0.557	-0.006	0.965	-0.121	0.342
HR	0.088	0.490	0.163	0.198	0.189	0.135	0.178	0.160	-0.011	0.932	0.039	0.758
Vo2/kg	0.112	0.377	0.183	0.148	-	-	0.149	0.239	0.013	0.920	-	-
Time	-0.259	**0.039**	0.203	0.107	0.745	**0.001**	0.239	0.057	0.149	0.240	0.613	**0.001**

PTE = peak torque extension, PTF = peak torque flexion, V'E = ventilatory equivalent, RER= respiratory exchange ratio. HR = Heart rate.

Pollock *et al* [20] reported that 15% to 30% improvement in VO_2 max can be expected with endurance training. There was an extremely high significance of improvement of aerobic capacity with the present study. VO_2 max improved from 41.0 ml/kg/min to 50.34 ml/kg/min ($p<0.0001$), hence the oxygen utilization improved, improvement in the relative exercise intensity. They also reported no change or a slight decrease in the maximal heart rate, while Wilmore *et al* [21,22] reported a possible decrease in HR max in response to endurance training for individuals with HR max in excess of 180 beats per minute. In the present study there were no significant changes in the HR max of the cadet.

The present study supported the findings of Koutedakis *et al* [23], where they assessed strength and endurance changes in young dancers after 12 week training. They documented a significant increase in both VO_2 max ($p>0.004$) and strength ($p<0.001$). John Schuna [24] assessed whether a summer break of Army ROTC cadets had an effect on endurance or not and documented a significant reduction in VO_2 max after the break of 3 months. As in the present study there was no such break in the NCC cadet training, significant reduction was not found in endurance.

The total time of running also showed significant improvement of 2.3 minutes of increased running. Better cardiovascular response and improved oxygen uptake are accountable for the change. The present study supported the study done on army recruits of U.S military by Daniels *et al* [25]. They showed a 2 fold increase in aerobic power of men than women. However in the present study only male cadets were taken.

Ratio of flexors and extensors had positive correlation with peak torque extension movement. The endurance parameters had significant correlation with the other physical fitness parameters. More the time of running more is the VO_2 max and isokinetic strength; hence a strong positive correlation was reported.

However, the limitation of the present study was that it didn't evaluate the gender specific fitness outcome differences as evaluated by Yanovich *et al*. [26], they gave 4 months of basic training in 109 females and 28 males of the Israeli Defence Forces and concluded that there was only a small overlap in physical abilities at the beginning of BT, which indicated vast differences in physical fitness between the genders.

5. Conclusion

National cadet corps individual showed extremely significant improvement in their physical fitness after an 8 week interval of their training which consisted of drills, camps, obstacle courses etc. There was a significant improvement in the cardio respiratory fitness i.e. VO_2 max and in isokinetic strength of knee flexors and extensors and the ratio of these two. Hence, it was concluded that the NCC training was effective and induced beneficial and significant improvement in the physical fitness components of their cadets.

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