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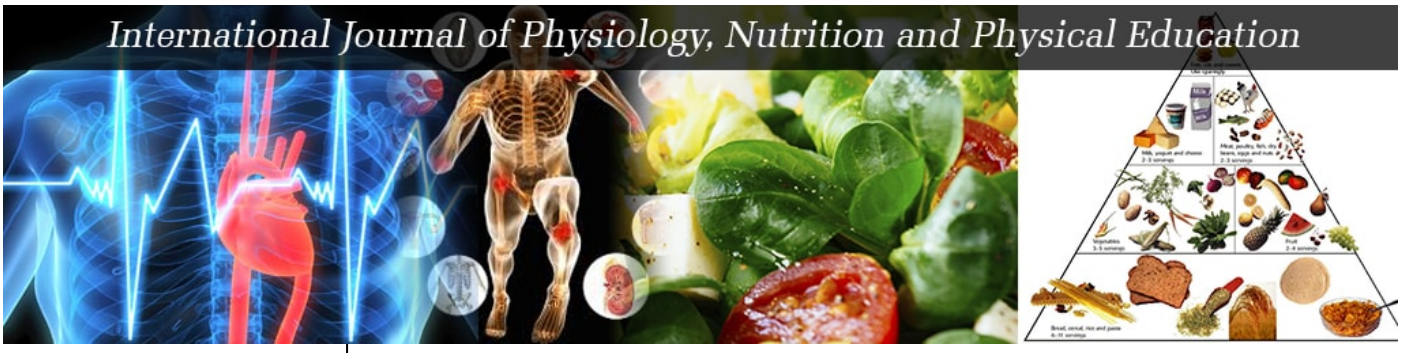

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Dominant physical, physiological and anthropometric variables helpful for performance enhancement in cross-country skiing

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Abstract
Objective: The current study focuses on the physical, physiological and anthropometric variables associated with the success of cross-country skiers.
Methodology: Relevant literature was reviewed from many peer review publications. Cross-country skiing differs widely from alpine skiing and snowboarding as it is an endurance event usually run on a circular track in the snowbound areas. Cross-country skiing requires full effort from an athlete, be it physical, physiological or anthropometric. The Snow skiing is a game which requires almost all physical, physiological, anthropometric and biomechanical parameters for improving performance of athletes. These parameters are Aerobic Capacity, muscular strength, flexibility, oxygen uptake, cardiac output, muscle size, weight, body mass index, lean body mass, air drag, snow ski friction, ground reaction forces, radius of the turn and trajectory of the skies and center of mass. But in this study we are concerned with only physical, physiological and anthropometric parameters essential for the success of cross-country skiers. Based on the various studies we have chosen those variables which play a dominant role in improving performance or are at least helpful in showing ones peak performance.
Conclusion: While concluding we can say that variables like general strength and kinetics, upper body power, lactate threshold, oxygen uptake, body composition are essential for cross-country skiers.

Keywords: Cross-country, skiing, aerobic capacity, physical, physiological, performance

Introduction

Cross-country skiing is a racing event. Cross-country skiing has been classified into two major groups; classic technique which means that the skis remain parallel in the same direction towards which the skier is moving and the other one is named as freestyle or ski skating techniques in which a force of pushing is needed and the skies make "V" shape. In this technique the skies move outwards form the direction towards which the skier is moving. Classical style consists of diagonal stride, in this both skies move parallel to each other. While as, free style skiing is like ice skating. In free style skiing one leg slides at once and the other in the next slide [1]. Cross-country skiing is not as easy as Alpine skiing and snowboarding, as it requires a lot of efforts both physical as well as physiological. Cross-country skiing demands highly physical and muscular efforts consisting of muscles of both upper as well as lower extremities. Due to the initiation of new techniques and conditions upper body power plays a vital role in performance enhancement, as it has been calculated that more than 50% of propulsive power is produced by the upper body in cross-country skiing [2]. A study by Holmerg *et al.* (2007) showed ratios between VO2 peaks obtained in double poling and diagonal skiing of 0.86(0.82-0.91) [3]. A number of studies have reported that best cross-country skiers should have high, absolute as well as relative values of aerobic power [4, 3]. Cardiac output is considered to be most essential and predominant determinant of oxygen delivery and a tight relationship has been found between oxygen delivery and its utilization based on the wide range of metabolic demands. Moreover the results of thesis given by [5] on physiological demands of competitive and successful cross country skiers show that the VO_{2max} is also a performance indicator among both successful male and female cross-country skiers.

The problem has been stated as the relationship between motor abilities and smash skill of badminton players of Haryana. Motor abilities namely agility, balance, flexibility,

A high oxygen uptake is also beneficial for double-poling technique among both men (DP60 VO_{2mean}) and women (VO_{2peak}).

Methodology

The current study is based on the literature published from the year 1968 to 2015. All the relevant and important articles were searched from various data base like Google Scholar, PubMed, Ovid and Research Gate. The search items used were, Cross-country skiing, snow skiing, essential variables in cross-country skiing, physiology of cross-country skiing and anthropometric variables in cross country skiing.

Inclusion criteria: Our study mainly focused on the articles relating to physical, physiological and anthropometric parameters associated with cross-country skiing.

Exclusion criteria: The study excluded the articles relating to alpine skiing or snowboarding variables. Moreover, the biomechanical and psychological variables relating to cross-country skiing were also excluded. Age and gender difference in cross-country skiing was also excluded.

General Strength and kinetics

A study conducted by +, studied the relationship between strength, maximal speed in skiing and pole and leg kinetics as well as kinematics. Total 16 elite skiers have participated in this study. The subjects were instructed to perform three skiing speed tests on a treadmill using both double poling technique and diagonal stride. To test the general strength many tests have been conducted like isometric leg test, bench press, brutal bench etc. Relationship between strength exercise and V_{max} were based on technique. There was a relation between upper body strength and performance among sprint skiers. Moreover, coordination of movements was essential for peak performance [6].

Upper Body Power (UBP)

One study has been conducted to examine maximal oxygen uptake on a treadmill running as well as double polling on ski ergometer. Maximum power output was also checked by a progressive double poling power test. Ten subjects (five male and five female) have participated in the study. Maximum aerobic power has been tested while using different analyzers. Upper body peak test was evaluated by open-circuit system as used for the treadmill test and for double polling test in cross country. Computer based arm ergometer was used. Upper body test was done on the other day using same ergometer with an increased workload after every 20s. The results found did not show any notable difference in variables among both sexes. Moreover, in male athletes maximum aerobic power and UBP were higher in both tests. There was no notable difference between Vo_2 peak and performance among both sexes [7]. Another study was conducted, comparing upper body power among cross-country runners and skiers. A total of 195 subjects were selected and examined using a street arm ergometer. There was a strong relation between upper body power and velocity of race among skiers. The cross country runners were having 46 percent lower upper body power than skiers. This means that UBP is essential for cross-country skiers [8].

Cardiac output and blood flow

It has been found that Maximal cardiac outputs and stroke volume of elite cross-country skiers is of 40 l min-1 and above 200 ml with maximal oxygen uptake values above 6 l min-1 [9]**.** There is a close relationship between higher maximal cardiac output and reduction in heart rate at the time of submaximal exercise [10, 11].

Lactate threshold and peak oxygen uptake

Carlsson (2015) has studied the physiological demands of successful cross-country skiers. In this study lactate-threshold, maximal and peak oxygen uptake, mean oxygen uptake double poling, body composition, knee extension and vertical jump tests were conducted. The results of this study specified that distance performance is increased if the lactate is not accumulated or is least accumulated. This means that a skier having a less accumulation of lactate will perform better in speed skiing. Double poling speed and maximum double poling power output are essential for sprint and distance performance. There is no correlation between knee extension and vertical jump on ski ergometer performance test [5].

Oxygen uptake

The results of one of the study show that the VO_{2max} is also an index of competitive distance performance among both sexes in cross-country skiing. Moreover, while using double poling technique, high oxygen uptake is essential for distance performance among both sexes (DP60 VO_{2max}) (VO_{2peak}) [5].

A number of studies have shown that well performing cross-country skiers possess high aerobic power, both in absolute and relative values based on some exceptional cases. Maximal aerobic power test was conducted on 37 athletes including cross-country skiers, rowers and some cyclists [12]. One study states that maximal oxygen uptake increases with an increase in age from 55-60 to 75-80 but at the later stage it reduces again [4]. A study was done on the effect of body mass on performance in cross country skiing. It was studied that heavy skiers were benefited and were faster at the terrain but not at the uphill [13]. Upper body of successful cross-country skiers is more essential. This development is due to the skating technique, but in case of classical technique upper body and double poling (DP) are also essential for better performance [14]. Thus, maximal oxygen uptake is considered crucial for performance enhancement in cross-country skiing. A study based on competitive international elite skiers [3] examined oxygen uptake at the time of maximal exercise and exhaustion during diagonal skiing, running and double poling. The skiers attained their highest VO_{2max} at the time of diagonal skiing (+3.8%; range 1-10%), pointing to the important functions of muscle mass. All the skiers attained greater VO2 max when both arm and leg exercise were compared with running, despite similar maximal HR, the data supports that systemic oxygen delivery determines highest limit of VO2 in normal humans. Cross-country skiing in comparison with other endurance sports is a complicated form of racing with a broad and diverse locomotion types on various types of slopes. Hence, this discovers that, while comparing endurance sports with skiing techniques, the skier's aerobic capacity is inevitable for performance.

1. It is also studied that elite skier reached their maximum oxygen uptake upto 90% in double poling [14].
2. There has been a close relationship between upper body aerobic power and the performance in cross-country skiing [7, 8, 15].

Maximum oxygen uptake has been assessed on 51 participants of elite skiing. They were grouped into three categories. The study shows that VO_{2max} was significantly higher in male world-class skiers than other elite skiers. This means that Vo_{2max} difference directly effects performance among competitive skiers [16].

Upper body time trials

The current study aims to find out the performance predictors by the ski specific tests. In order to find out the lactate threshold, ski economy and maximum oxygen uptake three field tests were conducted using roller skies and 10 km skating time trial was performed randomly. It was found that upper body time trial was very important for performance enhancement in cross-country skiing. However, a negative correlation was found among 1 km upper body time trial on snow and seasonal rank among males [15]

Body composition

A study has been conducted which aims to detect the anthropometric characters (body composition and body dimension) essential for the world class skiers. Moreover body height and lean body mass were supposed to be essential for peak speed in the techniques like double poling and diagonal stride. Two tests were conducted on 14 elite skiers in which peak speed was tested with double poling and diagonal stride was tested using a treadmill. The body composition and body dimension were examined by dual energy x-ray absorptiometry (DEXA). There was no correlation between body height and technique. However, there was a positive relation between lean body mass, body mass index (BMI), total lean mass and relative lean mass of trunk, arms and legs to diagonal stride peak speed [16].

Conclusion

While concluding we can say that contrary to the previous investigation, a current report on the world-famous Austrian National Team, resulted that success of skier was strongly correlated with their aerobic power (Neumayr 2003). Indeed some other studies also agreed with the study of Neumayr 2003. Hence it has been proved that professional ski racing performance enhancement depends on various variables and cannot be judged from one or two physical and physiological parameters. Moreover, among these variables two appear to be more essential, i.e. aerobic power and muscle strength. In contrast, the former is essential to meet the dominant energy requirements during training and competition while as, the latter is to provide a quick and adequate recovery within short intervals and to overcome stress in the long duration training sessions in order to be a successful skier world championships and Olympic competitions. So there are tight relations between success and aerobic power. Regarding strength we can say that strength is not only important for performance improvement but also essential for injury prevention. Flexibility is also essential determinant of injury prevention, strength and stability. A little difference has been found between National, Divisional and Club level skiers.

Various studies have been done considering the importance of muscle mass involved in attaining the maximal oxygen uptake. Most of the studies have suggested that combined use of arm and legs in skiing induced greater oxygen uptake. Cardiac output depends upon the capability of cardiovascular system so as to transport oxygen to the skeletal muscles as skiing needs a wide range of metabolic. A higher maximal cardiac output is directly related to a reduced heart rate during submaximal exercise and a higher maximal oxygen uptake. So we can say that cardiac output is also of great importance, which helps an athlete to perform optimally and show his peak performance.

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