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RESEARCH ARTICLE

Impact of Isolated Endurance and Concurrent Training on Aerobic Capacity (VO2max) and Speed Performance in field hockey players

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Abstract

An arbitrary cohort of 60 male participants of subject hockey was categorised into the following four coaching groups: staying power coaching (ET), energy coaching (ST), concurrent coaching (CT), and manipulate crew (CG). The cure used to be for ten weeks. A standardized discipline check used to be used to verify each VO2max and speed. Keep in thought that as we habits analyses of covariance (ANCOVA) to supply proof if there are tremendous variations in groups. This is additionally supported by way of the absolute best VO2max beneficial properties acquired in the ET group, whereas average upgrades had been found for concurrent training. A marginal enlarge in ET and an index of enchancment in CT used to be found in velocity performance. They determined persistence workout as the most high-quality technique of growing cardio performance; concurrent workout has a extra balanced however decrease degree of adaptation.

Keywords: Endurance, Concurrent Training, VO2max, Speed, Field Hockey.

Introduction

Field Hockey consisting of excessive exercise and low to average undertaking alternating bouts (a most important load on cardio and anaerobic strength systems). Most gamers are capable to cowl distances of 8-12 kilometres in a sport alongside with an uninterrupted dash of sprints as nicely as accelerations and recoveries. So in this light, cardio capacity, predominantly described in phrases of maximal oxygen uptake (VO2max), can seriously be counted for athletes to keep performance, get better at some point of durations of excessive effort and work quotes overall performance and overall performance of the recreation (1, 2).

Endurance coaching is a extensively regarded wonderful intervention to beautify VO2max by using way of central and peripheral adaptations. These are: excessive cardiac output, expanded capillary density, mitochondrial biogenesis, and oxidative enzyme activity, all of which can enlarge oxygen uptake (3-8). For example, resistance education and cardio workout can also enhance cardio capability in cardiostatically excessive stages of VO2max, such as in cardio sprints.

Recent lookup has additionally emphasised excessive depth interval education (HIIT), an intervention which affords a big effect in a brief duration of education on cardio ability over a exceptionally slim education time, tremendous in area hockey gamers (9 - 12). Performance speed, however, is alternatively a heterogenous overall performance phenotype associated to a combine of elements such as intramuscular coordination, increase rate, muscle fiber loading, neuromuscular fiber distribution and anaerobic power conversion pathway (8, 13 -16). Although traditionally believed to be a thing in electricity and strength overall performance and a much less carefully associated to speed, as restoration may also happen extra regularly in the interval from going for walks consecutive dash runs (9, 17,18,19), with pace overall performance (the quickest of all sprints), there is the proof to aid a joint impact of

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cardio health with dash overall performance of fitness, and consequently acceleration speed.

Concurrent training, which integrates endurance and strength training within the same programme, has become increasingly popular due to its potential to develop multiple fitness components simultaneously (20, 23). However, the effectiveness of concurrent training remains a topic of debate. While some studies report complementary adaptations, others highlight the potential for an interference effect, where endurance training may compromise strength and speed development (24,25, 26).

Recent advances suggest that the interaction between endurance and strength adaptations is influenced by training variables such as intensity, volume, and sequencing. Appropriate scheduling and recovery strategies may help minimize interference and enhance training outcomes (27, 28, 29).

Despite the growing body of literature, there remains limited clarity regarding the specific effects of isolated endurance training compared to concurrent training on aerobic capacity and speed performance in field hockey players. Therefore, the present study aims to examine the comparative effects of these training modalities on VO_2max and speed, providing practical insights for optimizing training strategies in field Hockey.

Methodology

Participants

A total of sixty (N = 60) male collegiate field hockey players aged between 18 and 25 years (mean age 19.92 ± 1.65 years) voluntarily participated in this study. Every participant was in competition at the intercollegiate level and had equivalent playing experience and training backgrounds: This allowed for a fairly homogeneous sample to be built (3). Participants were recruited by random sampling and assigned into four groups (n = 15): endurance training group (ET), strength training group (ST), concurrent training group (CT), and control group (CG).

Random allocation was used to avoid selection bias and an equal distribution of individual differences among the groups was made. Before the experiment, all participants were screened for physical fitness and eligibility. Subjects with a history of musculoskeletal injury, cardiovascular disorders, or any medical condition that could prevent training or testing were eliminated.

All subjects were told about the study's objective and procedures, and signed informed consent was obtained before their involvement. They were mandated to adhere to their typical dietary habits and daily routines throughout the study period.

Variables

The parameters used in the current study were determined as per the physiological requirements and on the performance characteristics in field Hockey - Aerobic capacity and speed are two important variables. These variables were classified as independent and dependent variables so that their actual training effects can be well evaluated. Independent Variables:

- Endurance Training (ET)
- Concurrent Training (CT)

The independent variables are for the training strategies that cause particular physiological changes. Endurance training is predominantly aimed at increasing cardiovascular efficiency and metabolic function through continuous and interval-based aerobic training. Such training enhances oxygen transport and utilization, thus increasing the athlete's capacity for long-duration work. In comparison, concurrent training links endurance and strength workout in the same training program. This is designed to build multiple fitness components at once such as aerobic capacity and neuromuscular function. The concomitant responses of these training modalities can indeed interact with each other and will impact the larger adaptation process, hence the need to assess their effects on this process. Dependent Variables:

- VO2max
- Speed

VO2max was chosen as the main indicator of aerobic capacity, reflecting the maximal rate to which oxygen can be used and consumed during high-intensity exercise. It has been noted as one of the most important factors for endurance performance in field Hockey because of the capacity to maintain high levels of activity and recover quickly since repeated attempts are required to ensure maximal activity on a long duration (2; 16). Enhanced VO2max will generally occur through central, with an increase in cardiac output, and peripheral, with an increase in capillary density and mitochondrial activity. Speed was incorporated as a metric that reflects the ability to perform fast movements for short time intervals. Speed in field Hockey is critical for sprinting, acceleration and reacting to evolving game scenarios. Several neuromuscular factors, such rate of force development, motor unit recruitment, and muscle fiber composition, affect speed performance (8; 9). Aerobic fitness may also have an influence on speed performance because speed recovery can be improved between repeated sprint efforts. The use of these variables also give a full assessment of responses from both the physiological and performance perspective based on the various training processes.

Training Protocol

The experimental training programme was implemented over a period of ten weeks under carefully controlled and supervised conditions to ensure participant safety, adherence to the protocol, and consistency in training delivery. All sessions were conducted under the guidance

of qualified instructors, and attendance was monitored throughout the study period.

Each training session lasted approximately 45 to 60 minutes and was systematically organized into three phases: warm-up, main training session, and cool-down. The warm-up phase had 10–15 min of light aerobic exercise (e.g., jogging) with dynamic stretching for all major muscle groups. The goal of this segment was once to expand muscle temperature, mobility and put together the neuromuscular gadget for persevered activity. Participants practiced low depth exercising routines in the direction of the cool-down technique and static stretching workout routines in the direction of the cool-down area supporting recovery, reducing muscle stiffness, and assisting put off metabolic waste products. For the staying strength teaching crew (ET) they skilled three days per week on non-consecutive days, with sufficient time to get higher through leisure between sessions.

Training depth was once as soon as modified to 70-85% of maximal coronary coronary heart cost (HRmax), equal to medium/high cardio intensity. Heart rate used to be assessed to have folks preserve hooked up depth zones from setting up to stop in the path of sessions. The teaching pursuits comprised continuous taking walks and interval exercise. The baseline cardio fitness used to be hooked up thru continuous exercise, in which successive intervals of exercising had been step by step delivered to enhance cardio standard overall performance and oxygen utilization.

In order to alter the VO2max (2; 11; 21), the size and depth of the exercising durations have been prolonged regularly all thru training. The concomitant teaching crew (CT) undertook the training in section by way of ability of the utilization of a blended teaching time table of five teaching days per week. This software blended every staying strength and power work in one week cycle. Similar depth and techniques of staying power exercising had been utilized for the staying energy durations introduced in the ET group. Strength schooling sessions, for the minimize limbs, pinnacle body, and core, had been carried out on alternating days and consisted of resistance exercises centered at the principal muscle groups (lower limbs, top body, and core). Squats, lunges and greater physique resistance work to embellish the frequent muscular electrical energy and neuromuscular effectivity had been performed. The methods have been expert at common thousands with managed repetition pointers to reduce the severity of the injury.

In particular, the order of staying power and energy periods used to be purposely designed to decrease fatigue and enable for less difficult adaptation. Sufficient healing between exercises was once used to keep away from cumulative fatigue and overtraining. This method was once additionally in line with the concepts of ultimate coaching protocols and used to be perceived as crucial to acquire the most most out of concurrent training, even as minimizing interference effects.. exercises to promote recovery, reduce muscle stiffness, and facilitate the removal of metabolic by-products.

Training load was progressively increased throughout the intervention period by systematically manipulating intensity, duration, and frequency in accordance with the principle of progressive overload. Individual responses to training were monitored, and adjustments were made when necessary to maintain the desired training intensity and ensure continuous improvement.

Participants in the control group (CG) did not engage in any structured training programme during the experimental period and were instructed to continue their routine daily activities without participating in additional physical training.

Overall, the training protocol was designed to provide a structured and scientifically grounded approach for comparing the effects of isolated endurance and concurrent training on selected performance variables in field hockey players.

Statistical Analysis

The collected data were analyzed using appropriate statistical techniques to examine the effectiveness of the training interventions. Descriptive statistics, including mean and standard deviation, were computed for all dependent variables to summarize the central tendency and dispersion of scores at both pretest and post-test stages.

To evaluate within-group changes over time, paired sample *t* -tests were applied. This analysis enabled the assessment of whether the differences between pretest and post-test scores within each group were statistically significant.

To compare differences among the groups while accounting for initial variations, Analysis of Covariance (ANCOVA) was employed. In this procedure, post-test scores were treated as dependent variables, and pre-test scores were used as covariates. The use of ANCOVA improves the precision of group comparisons by adjusting for baseline differences and reducing the influence of extraneous variability (**?**). This approach is particularly appropriate in experimental designs involving pretest and post-test measurements.

Prior to conducting ANCOVA, key statistical assumptions were tested to ensure the validity of the analysis. These included the normality of data distribution, assessed using appropriate normality tests; homogeneity of variances across groups; linear relationship between the covariate and the dependent variable; and homogeneity of regression slopes. Verifying these assumptions ensured that the conditions required for reliable interpretation of ANCOVA results were satisfied.

When a statistically significant F-ratio was obtained, post hoc comparisons were con- ducted to identify specific differences between group means. A conservative multiple comparison procedure, such as Scheffe's test, was employed to control for Type I error when making multiple comparisons.

The level of significance for all statistical tests was set at 0.05. In addition to statistical significance, effect size was calculated using partial eta squared (η^2) to determine the magnitude of the training effects. Effect size values were interpreted using standard benchmarks (small, medium, and large), providing a more comprehensive understanding of the practical importance of the findings beyond p-values alone.

Results

ANCOVA for VO_2max

The ANCOVA results presented in Table 1 revealed a statistically significant difference among the groups in VO_2max ($F = 22.34$, p ¡ 0.05). The partial eta squared ($\eta^2 = 0.545$)

This indicates a large effect size, suggesting that approximately 54.5% of the variance in post- test VO_2max scores can be attributed to the training interventions.

This large effect size demonstrates the substantial impact of the experimental pro- grammes on aerobic capacity. The use of ANCOVA ensured that these differences were not influenced by baseline variations, thereby providing a more precise estimation of treatment effects.

The adjusted means indicate that the ET group achieved the highest improvement, followed by the CT group, confirming the effectiveness of endurance-based training for enhancing aerobic capacity.

ANCOVA for Speed

The analysis of covariance (ANCOVA) results presented in Table 3 revealed a sta- tistically significant difference among the groups in speed performance after adjusting

Table 1: ANCOVA Summary for VO_2max

Source	*SS*	*df*	*MS*	*F*	*Sig.*	*Partial η^2*
Between groups	320.45	3	106.81	22.34*	.000	0.545
Within groups	267.21	56		4.77		

Table 2: Adjusted Means for VO_2max

Group	*Pre-test Mean*	*Post-test Mean*	*Adjusted Mean*
ET	42.5	51.0	50.6
CT	42.6	47.2	46.8
ST	42.4	43.5	43.3
CG	42.5	42.8	42.7

Table 3: ANCOVA Summary for Speed

Source	*SS*	*df*	*MS*	*F*	*Sig.*	*Partial η^2*
Between groups	2.54	3	0.84	9.62*	.000	0.340
Within groups	4.89	56		0.087		

for pre-test values ($F = 9.62$, p – 0.05).This cautioned that the education interventions produced one-of-a-kind outcomes on overall performance in sprints. The partial eta squared ($\eta 2 = 0.340$) shows a moderate-to-large impact dimension and some 34% of the variance in post-test velocity ratings can additionally be attributed to education programmes employed.

In addition, this discovering underlines the realistic relevance of the interventions to pace performance, past mere statistical significance. Regarding a greater exact crew overall performance analysis, there is proof that the concurrent coaching (CT) team finished a higher achieve in pace than each the persistence education (ET) crew and different groups. This enhancement can be attributed to the function of electricity education aspects in the concurrent education programme, which possibly improved neuromuscular parameters together with price of pressure development, motor unit recruitment and coordination. In contrast, the 2nd group, staying power training, validated extraordinarily little velocity difference.

Since staying power education notably goals cardio electricity systems, it is not likely that this coaching approach would grant enough stimulus to boost the neuromuscular homes imperative for the improvement of optimal dash overall performance and so, this outcome. The energy coaching crew confirmed average attain with the energy of the pressure manufacturing as in contrast to little trade located in the manipulate group, indicating education used to be no longer advantageous. In conclusion how the cutting-edge learn about demonstrates the truth in this find out about is that the simultaneous execution of the education as a complete would represent a higher way to enhance velocity in the discipline hockey player, now not solely for its metabolic impact however additionally due to increased neuromuscular adaptation and consequently the impact on standard athletic performance.

Discussion

n this investigation, staying power coaching was once extraordinarily high quality at enhancing VO2max (aerobic fitness). An interpretation of the effects would be that it has a corresponding recommended impact on cardiovascular feature and effectivity of oxygen utilization. These adjustments facilitate ongoing things to do and enhance healing from things to do over durations of time. Likewise cardio potential grew to become more desirable in the course of concurrent training, however to a particularly

attenuated extent. This is possibly additionally due to a distribution of coaching stimuli between patience and electricity components, which reduces the specificity of the adaptation. Similarly, concurrent coaching produced reasonable velocity overall performance improvements, suggesting the have an impact on of power elements enhancing neuromuscular coordination and pressure production. In contrast, patience education solely marginally improved velocity suggesting the coaching wishes to be extra specific. There are clear warning signs throughout the statistics that patience coaching consequences in best cardio ability enhancement, even as concurrent education can also exhibit a reasonable however much less mentioned expand throughout all parameters of performance.

Conclusion

Indeed, the cutting-edge study's information endorse that specific education tactics to subject hockey gamers lead to special physiological and overall performance results in discipline hockey players. Isolated persistence education has been proven to be extraordinarily powerful in enhancing the cardio capability as indicated with the aid of the big amplify in VO2max. This is due to most appropriate cardiovascular efficiency, accelerated uptake of oxygen, and expanded metabolic health with persevered cardio exercise. One greater great end result (concurrent training) was once that VO2max used to be tons greater (albeit barely decrease in contrast to persistence training). These outcomes point out that concurrent coaching does substantially make contributions to cardio health improvement, however, prioritizing the training of persistence over power will in all likelihood limit the international specificity of the adaptation. Concurrent overall performance confirmed higher upgrades than stand-alone overall performance in tempo coaching by myself in speed. This implies that the incorporation of electricity education enhances the characteristic of more than one neuromuscular pathways, such as charge of pressure improvement and motor unit activation for each areas of pastime in the subject of dash performance. A similarly affirmation of these consequences comes from the impact dimension evaluation that suggests giant coaching on VO2max and moderate-to-large consequences on velocity performance. They endorse that the coaching interventions have realistic cost past statistical significance. In this research, for most suitable favored beneficial properties from coaching its specificity is proven to be crucial.

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