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Original Article

Gender Difference in Fatigue Index and its Related Physiology

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Abstract

Fatigue index exhibits gender difference. This study was carried out to compare fatigue index of young, national level male and female field hockey players; and to explore physiological variables contributing to this difference. We measured running-based anaerobic sprint fatigue index and selected physiological parameters in male and female players matched for age, duration of training, diet, habitual physical activity, body weight and BMI. The male hockey players showed lower resistance to repeated sprints fatigue than the female players. Body weight, BMI and power variables positively correlated to fatigue index in both sexes; while lean body mass and age in males only, and body fat % in females only were found to be correlated to fatigue index. Difference in lean body mass, body fat %, strength and anaerobic power might be responsible for gender difference in intermittent & repeated sprints fatigue index observed in studied players.

Introduction

Fatigue is a reversible loss of ability to maintain the required power output to continue muscular work at a given intensity, associated with decrement in muscular performance and increase susceptibility to injury (1, 2). Fatigue results from a combination of neuromuscular system impairments for which the causes can be: decreased rate of energy delivery & substrate availability (phosphocreatinine depletion, glycogen depletion, prolonged oxygen depletion), accumulation of metabolic by products (inorganic phosphate, H^+ ion, lactic acid), increased temperature, failure of muscle contractile mechanism and alteration in neuronal control of muscle contraction including failure of neural transmission & inhibition from central nervous system (3, 4). The cause of fatigue is also specific to nature of the task or exercise associated (1, 5).

The ability to resist intermittent and repeated sprinting fatigue can be assessed by measuring fatigue index (FI) using RAST (Running-based Anaerobic Sprint Test) (6-8). Fatigue index indicates the rate at which power declines, hence indirectly provide an assessment for ability to maintain required power output & anaerobic performance over time. The smaller the value of FI the better is the ability to resist fatigue.

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Male and female subjects respond differently to exercise and physical activity in terms of fatigability. The gender difference in muscular fatigue has been reported earlier (9-11). The specific physiological mechanisms responsible for this gender difference in fatigue are not precisely understood (9). However many theories to explain it have been suggested like difference in muscle mass, difference in substrate utilization for ATP production and difference in neuromuscular activation including central motor drive, apart from exercise intensity (9, 11-16).

Field hockey is an intermittent endurance game which demands large number of repeated sprints and accelerations-decelerations (17). The players should be able to produce high power out & speed sprints of short duration in succession with little recovery time between them (18). For having a good repeated sprint ability, the players should have a fast recovery rate & resistance to fatigue (19). Hence, understanding the factors affecting resistance to fatigue is crucial for better performance. To explore more about physiological factors responsible for this gender difference, we studied FI and other physiological parameters in a group of young, national level male and female field hockey players.

Methods

The present cross sectional study was carried out under the department of Sports-Exercise Medicine and Sciences at North-East Regional Centre, Sports Authority of India, Imphal, Manipur, India. Total 18 male & 13 female field hockey players aged 12 to 20 years, participated voluntarily in this study. All participants were national level players, undergoing similar field hockey training. The male and female groups were matched for age, duration of training, diet and habitual physical activity. The male and female players also had comparable BW & BMI (Table I). All the players were found fit for the study in a medical screening & examination. A well informed consent was obtained from the participants and the study was approved by the Ethical Committee of the institute.

All the tests were done on outdoor synthetic hockey track in morning hours, between 7 am to 8:30 am around a temperature range of 25±2°C, with relative humidity of 60-65%. During the tests, throughout encouragement and motivation was provided to players. They were instructed to come after a sound night sleep with no physical exertion before 12 hours of the test. No caffeinated drinks or solid food were allowed 4 hours before the test. The purpose and the procedures of every test were explained clearly to all the participants.

RAST was done to measure Pmax (maximum power), Pmin (minimum power), Pavg (average power) and FI as per the standard protocol (6, 20). Body weight (BW), Lean Body Mass (LBM) and Body fat % (BF%) were measured using TANITA Body Composition Analyzer (TBF310 Model, Japan) which used bioelectrical impedance analysis technique. Body Mass Index (BMI) was calculated using measured height and body weight.

Hand grip strength of both sides was measured using a hydraulic handgrip dynamometer (Baseline Hand Evaluation set 12-0100, NY 10602, USA). Upper limb strength was estimated using Seated Shot Put test (SSP) following the standard methodology (21). Vertical Jump (VJ) test was done to measure lower limb strength (22, 23).

Data analysis was done using SPSS (Statistical Package for Social Science) version 20 software. Comparison of various measured variables between male & female players was done using unpaired t test. Pearson's correlation was calculated to find correlation between FI with other variables in both the groups. Statistical significance was chosen at 0.05 levels.

Results

Measured data was tabulated and statistical analysis was performed. Table I shows physiological parameters measured in both groups and results of comparison by unpaired t test. Correlation of these parameters with fatigue index is listed in Table II.

TABLE I : Comparison of physiological parameters between male & female field hockey players.

Parameters	*Group*	*Mean*	*Std. Deviation*	*Comparison by t test (p-value)*
BW (kg)	Male	53.61	7.358	.393
	Female	51.23	7.780	
LBM (kg)*	Male	43.33	4.602	.003
	Female	38.15	3.848	
% BF*	Male	18.39	5.066	.001
	Female	24.85	3.955	
BMI (kg/m^2)	Male	20.06	1.731	.122
	Female	21.08	1.801	
Pmax (W)**	Male	514.89	116.439	.000
	Female	329.92	73.526	
Pmin (W)**	Male	332.00	90.078	.000
	Female	205.00	39.147	
Pavg (W)**	Male	425.50	94.686	.000
	Female	264.77	55.682	
FI (W/sec)*	Male	5.56	1.947	.001
	Female	3.31	1.182	
Left grip strength (kg)*	Male	36.50	5.079	.001
	Female	29.31	6.250	
Right grip strength (kg)**	Male	39.28	6.781	.000
	Female	28.31	5.345	
SSP (cm)**	Male	308.56	46.215	.000
	Female	236.15	23.801	
VJ (cm)**	Male	41.56	4.617	.000
	Female	34.38	3.501	

*p<0.05 - significant, **p<0.001 - highly significant.

TABLE II : Physiological variables significantly and positively correlated with fatigue index in the field hockey players.

Common to both sex	*Male players*	*Female players*
Body Weight	Age	% Body Fat
BMI	LBM	Vertical Jump
Seated Shot Put		
Left Grip Strength		
Right Grip Strength		
Pmax		
Pavg		

Discussion

Male players were found to have more fatigability than female players (Table I), indicating that the female players had better resistance to fatigue, and hence lesser decline in power over the subsequent sprints, as also reported in earlier studies (12, 24-26). FI of both male and female players were found to be positively correlated with BW and BMI (Table II), which explains that weight is the common influencing factor in causation of fatigue in both sexes. Higher BW requires relatively more force and power to produce acceleration and velocity. Thus A heavier player has to work at a higher intensity. As anaerobic metabolism is the dominant contributor of the power developed specially during initial sprints (27) and at higher exercise intensity (28), the more accumulation of fatigue inducing metabolites like lactic acid (29, 30) may occur with higher BW in repeated sprints, inducing early fatigue.

We also found few correlated parameters that were different in male and females. LBM was found significantly correlated to FI in male players only. When the two groups were compared, we observed that female players had significantly lower LBM than male players, even though their BWs were comparable (Table I). The males on the other hand had stronger grip, upper & lower limbs (Table I), indicating the generation of greater absolute force during muscular contraction at the same relative work load, as reported earlier also (11). The presence of higher muscle bulk in male players implies more oxygen demand. However, due to their generation of greater absolute force, there may be greater compression of the feeding blood vessels in the muscles as a result of the higher rise in intramuscular pressure, thereby limiting oxygen and nutrients supply, and metabolic waste product removal (12, 16). This greater mismatch of oxygen demand & supply increases the dependency on anaerobic metabolisms still further, leading to greater accumulation of fatigue inducing waste products (29, 30). Thus this muscle mass hypothesis is more important determinant for repeated sprints fatigue resistance among the males who had higher LBM.

On the other hand, BF% showed significant correlation with FI only in female players (Table II). The increase in BF% means more contribution to the BW by fat mass which generates no power, but has to be carried along during repeated sprints. This fat mass might be increasing the workload in female players, contributing to fatigue to some extent but not as much as factors responsible for fatigue in male players. The predominance of aerobic metabolism in females was also suggested by the

significantly lower anaerobic capacity as assessed by RAST (Pmax, Pmin, Pavg) (Table I). Thus greater resistance to fatigue among females might be due to their greater reliance on oxidative metabolism for ATP production (31), lesser dependence upon anaerobic glycolytic pathways & hence lesser production of the fatigue inducing waste products (32). As oxygen is required for fat utilization, females are reported to use more fat during submaximal exercise than males, resulting in more sparing of muscle glycogen (15, 31, 33). The estrogen itself is also believed to have glycogen spring properties (14, 15, 33).

We also studied strength variables in both groups and found that upper limb (SSP) and grip strength of both hands were positively correlated to fatigue index in both male and female players (Table II). Other than these, FI was found to be correlated with lower limb strength (VJ) only in female players. Age related increase in fatigability was found in male players, but not in female players. Our results showed positive correlation of Pmax and Pavg of the RAST with FI in both sexes, indicating lesser resistance to fatigue with more anaerobic metabolism. This observation suggests that the players who use their maximum power at start using anaerobic reserves tend to get early fatigue which can be explained by the metabolic waste accumulation theory (2, 3). Thus fatigability to intermittent and repeated sprint exercise, especially for later sprints, may be inhibited by increasing the aerobic metabolism and encouraging training to enhance aerobic capacity of the players (34, 35).

This study has identified the key physiological parameters significantly influencing the fatigue index and its gender differences. The BWs of the players need to be monitored regularly as higher BW is detrimental for repeated intermittent sprints. Within physiological range, the lower body fat among female players and lower LBM among male players might reduce fatigue during sports and exercise involving swift movements and sprints. Cautious maintenance of optimum LBM in male and BF% in female players, careful use of maximum strength and better regulation of exercise intensity and power output during field hockey match must be ensured to decrease overall ratio of anaerobic to aerobic metabolic contribution, & hence delay onset of fatigue and better fatigue resistance.

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Abbreviations:

ATP, Adenosine tri-phosphate; BF%, Body fat percent; BMI, Body mass index; BW, Body weight; FI, Fatigue index; LBM, Lean body mass; Pmin, Minimum power; Pavg, Average power; Pmax, Maximum power; RAST, Running-based Anaerobic Sprint Test; SPSS, Statistical Package for Social Science; SSP, Seated shot put; VJ, Vertical jump.

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