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ABSTRACT

Fitness for sports has a multifaceted characteristic which includes physiologically independent components such as aerobic and anaerobic capacities, muscular strength, power, speed and agility. The present study investigated the agility, aerobic and anaerobic capacities and muscular performance of Malay male state level rugby and hockey players and sedentary individuals as control. Thirty Malay male participants (Age: 16.1 ± 0.9 years old) were recruited in this study. The participants were divided into three groups: sedentary control, rugby and hockey, with 10 participants per group. All the participants were required to perform the following physical fitness assessments: agility via Illinois agility test, aerobic capacity via 20 m shuttle run, anaerobic capacity via Wingate test, and muscular power via standing long jump and muscular strength measurement via hand grip and back and leg strength tests. The main findings of this study were: 1) rugby group showed significantly higher leg power and aerobic capacity compared to the hockey group, 2) rugby group have significantly higher agility, muscular strength and power, aerobic and anaerobic capacities compared to the sedentary control group, 3) hockey group have significantly higher agility, muscular power, aerobic and anaerobic capacities compared to the sedentary group. We conclude that physical training in rugby and hockey at state level in Kelantan elicited increased physical fitness components among the players compared to their sedentary counter-parts.

Keywords: *Agility, Aerobic Capacity, Anaerobic Capacity, Muscular Strength, Muscular Power*

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INTRODUCTION

Sound physical fitness is a prerequisite to excel in most sporting events. Fitness can be developed with conditioning programmes that combined proper individual exercise modalities that are consistent with well-established principles of training (Chittibabua & Chandrasekaran, 2014).

Rugby is a field-based team sport requiring a variety of physiological demands due to repeated high-intensity sprints and a high frequency of contacts during the game (Duthie *et al.,* 2003). It is also one of the games that needs muscular power to excel in this game. Basically, there are two types of position in a rugby team, which are forwards and backs. Therefore, fitness level and anthropometry of rugby players in these two positions might vary from each other (Chong *et al.,* 2011). Using a global positioning system on elite Japanese rugby union players, the total distances ran in a game for the forwards and backs were 5731.1±507.8 and 6392.1±646.8 m, respectively (Yamamoto *et al.*, 2020). Besides that, it was reported that the running distances with high speed (>18.0 km.h^{-1}) covered by the forwards and backs were 317.4±136.9 and 715.0±242.9 m, respectively (Yamamoto *et al.*, 2020). Kruger and Smit (2012) have stated that rugby is an intermittent type of activity, which utilise both aerobic and anaerobic energy systems. Thus, the physiological demands of rugby league require the players to have highly developed speed, agility muscular strength and power, and maximal aerobic power (Meir, 1994).

Hockey is a game that requires skilful stickwork and a high fitness level among the players. Hockey is also one of the games that needs muscular power to hit the ball by utilising a hockey stick. Hockey requires skills such as passing, dribbling, hitting, pushing, trapping and receiving (Mitchell-Taverner, 2005). Hockey players require high aerobic and anaerobic power, good agility, joint flexibility and muscular development, and be capable of generating high torques during fast movements (Reilly *et al.*, 2000). The predominant metabolic pathways during hockey matches are aerobic and the metabolic responses are generally similar to those experienced in endurance activities (Reilly *et al.*, 2000).

Although aerobic metabolic pathways provide the dominant energy route, anaerobic activity is highlighted during the more crucial moments of the match and contribute directly to winning possession of the ball and to the scoring or conceding of goals. Hence, hockey is considered as an intermittent sport due to the pattern of repeated short bursts of high intensity activity interspersed with active and passive recovery. Such a physically demanding sports requires efficient lactate removal and rapid regeneration of phosphocreatine stores to allow for continuous sustained performance (Tomlin & Wenger, 2001).

Fitness assessment of athletes is pertinent to provide useful information for the selection of athletes and also help in designing or redeveloping training programmes to enhance sports performance of these athletes. To date, information on physiological profiles of Malay male adolescent athletes involved in rugby and hockey in Malaysia are limited. Both rugby and hockey are classified as field sports but the players in both these games may have differences in various fitness components due to the different physiological demands for each game. Therefore, the present study was conducted to investigate and compare the agility, aerobic and anaerobic capacities and muscular performance of Malay male state level rugby and hockey players with their sedentary counterparts as the control.

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METHODS

Participants

Thirty physically healthy Malay males, age ranged between 14 to 17 years old were recruited in this study. The inclusion criteria for rugby and hockey players were those who had represented the state of Kelantan in rugby or hockey competitions, while inclusion criteria for sedentary control group were males aged between 14 to 17 years old and were not involved in any competitive sports and exercise less than 2 times per week.

Experimental Design

In the present study, the participants were divided into three groups, with 10 participants per group (n=10). The 30 participants were assigned into three groups: (i) sedentary control group (C); (ii) rugby group (R) and (iii) hockey group (H). All participants were required to undergo anthropometric assessment such as body weight, height, percent body fat and fat free mass. Fitness assessments included agility via Illinois agility test, aerobic capacity via 20meter shuttle run, anaerobic capacity via Wingate test, and muscular power via standing long jump and strength measurement via hand grip and back and leg strength tests.

Anthropometric and Physical Characteristics Measurements

The body weight and height were measured with participants in light attire without shoes via a stadiometer (Seca 220, Hamburg, Germany). Participant's body composition such as percent body fat (% BF) and fat-free mass (FFM, kg) were measured by utilising a body composition analyser (Tanita, TBF-140 Japan).

Illinois Agility Test

Illinois agility test has been reported to be a reliable and valid test to determine agility in male athletes and it is significantly related to speed and leg power (Hachana *et al.,* 2013). To perform this test, the participant stood behind the starting cone, and when the whistle was blown, the participants started to sprint as quickly as possible for 10 meters, turned and swerved in and out of the four cones inside and then cross the finishing line. The running time to complete this course was recorded.

20 Meter Shuttle Run Test

Estimated maximum oxygen uptake (VO_{2max}) was determined via 20meter shuttle run test which is a commonly used to indicate aerobic capacity (Ramsbottom *et al.,* 1988). The participants were required to run for 20meter to and for in accordance with the timing of the "beep" sound from the CD player. The participants ran continuously until they could not follow the pace of the "beep". The estimated VO_{2max} was estimated based on the number of accomplished laps.

Wingate Anaerobic Test

Wingate anaerobic capacity test was based on cycling at a maximal speed for 30 s against a high braking force on a cycle ergometer (H-300-RLode, Groningen, Holland) (Manna *et al.,*

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2010). Mean power (MP), peak power (PP), anaerobic capacity (AC), anaerobic power (AP) and fatigue index (FI) were measured during this cycling test. After 5 min warm-up, the participants were instructed to complete 1 min of cycling at 60W, and immediately after 1 min, the participants cycled all-out for 30 s with verbal encouragement from the to encourage the participants to sustain an all-out performance. After 30 s of intense cycling, the participants were allowed to cycle without any resistance for approximately 3 min as a part of cooling down session.

Hand Grip Strength Test

This test was carried out by utilising a handgrip dynamometer (Jamar Joo105, USA). The reliability for the Jamar dynamometer is 0.82 (Hamilton *et al*., 1992). The participants were told to grasp the dynamometer with an unbiased hold, with thumb pointing up. The participants were required to take a full breath and exhaled, then the dynamometer was gripped as hard as possible for around 5 s. Three trials for each hand were performed and the highest value was recorded.

Back and Leg Strength Test

This test was carried out by utilising a back and leg strength dynamometer (Takei TKK 1858, Japan). The reliability for the back and leg dynamometer is 0.93 (Ten Hoor *et al.*, 2016). The chain was adjusted so that the knees are bowed at 110°. Before the test, the dial on the dynamometer was reset to 'zero'. When the participants were ready, the chain was pulled as hard as possible without twisting the back, and the legs and arms were kept straight. The participants were required to pull against the weight consistently with no jerky movement and the feet were kept level on the base of the dynamometer. Three trials were performed and the highest value was recorded.

Standing Long Jump

This test required a measuring mat to measure the distance of the explosive jump. The participants were required to remain behind a line set apart on the ground with feet marginally separated. Then, the participants were told to keep the knees bent prior to the jump to give a forward drive. The participants were required to jump as far as possible and land on both feet without falling backwards. Three trials were performed and the furthest value was recorded.

Statistical Analysis

Statistical analysis was done by using the Statistical Package for Social Sciences (SPSS) version 22.0. All results were presented as means and standard deviations [means (SD)]. One-Way ANOVA analysis and post hoc Bonferroni test were used to determine the differences of the measured parameters among groups. The normality of the data was established using Kolmogorov-Smirnov test. The difference was considered statistically significant at p-value < 0.05.

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RESULTS

Anthropometric and Physical Characteristics of the Participants

Table 1 shows the mean age, body height, body weight, body mass index (BMI), body fat percentage (%BF) and fat free mass of the sedentary, rugby and hockey groups. There were no significant differences between groups in these measured parameters.

Table 1: Mean age, body height, body weight, body mass index (BMI), percentage body fat (%BF), and fat free mass in the sedentary, rugby and hockey groups

Groups	Sedentary (n=10)	Rugby (n=10)	Hockey (n=10)
Age (year)	16.2 (1.0)	16.3 (0.5)	15.8 (1.1)
Body height (cm)	163.4 (7.1)	166.3 (5.8)	166.8 (4.6)
Body weight (cm)	52.7 (13.7)	58.2 (7.4)	60.4 (15.4)
BMI ($kg.m^{-2}$)	19.6 (4.3)	20.9 (1.4)	21.6 (4.7)
%BF (%)	23.6 (7.1)	17.8 (3.8)	22.4 (6.2)
Fat free mass (kg)	39.5 (7.3)	44.1 (13.0)	46.1 (8.2)

Abbreviations: %BF = Percent Body Fat; BMI = Body Mass Index

Muscular Strength and Power

The rugby group showed significantly ($p<0.01$) higher handgrip strength (HGS) in both dominant hand (DH) and non-dominant hand (NDH), and back and leg strength (BLS) compared to the sedentary group (Table 2). The score from the handgrip strength (HGS) test for the sedentary, rugby and hockey groups were 31.1(10.5)kg, 42.4(6.5)kg and 37.9(5.5)kg respectively in dominant hand (DH), and 29.2(9.4)kg, 41.1(7.4)kg and 36.8(6.3)kg respectively in non-dominant hand (NDH). For the back and leg strength, the average score were 101.4(35.8)kg, 145.3(26.6)kg and 133.2 (23.3)kg in the sedentary, rugby and hockey groups respectively.

Table 2: Handgrip strength, back and leg strength and vertical jump distance in the rugby,hockey and sedentary control groups

Groups		Sedentary (n=10)	Rugby (n=10)	Hockey (n=10)
HGS (kg)	DH	31.1 (10.5)	**42.4 (6.5)****	37.9 (5.5)
HGS (kg)	NDH	29.2 (9.4)	**41.1 (7.4)****	36.8 (6.3)
BLS (kg)		101.4 (35.8)	**145.3 (26.6)****	133.2 (23.3)

***, p<0.01, significantly different from sedentary control group*
Abbreviations: HGS = Hand Grip Strength; DH = Dominant Hand; NDH = Non-Dominant Hand; BLS = Back and Leg Strength

Both hockey and rugby groups showed significantly ($p<0.001$) higher leg power measured via standing long jump (SLJ) compared to the sedentary group, while the rugby group showed significantly ($p<0.05$) higher leg power measured via standing long jump (SLJ) test compared to the hockey group. The score from the standing long jump test for the sedentary, rugby and hockey groups were 150.6(30.5) cm, 221.0(12.1) cm and 195.0(21.3) cm respectively (Fig. 1).

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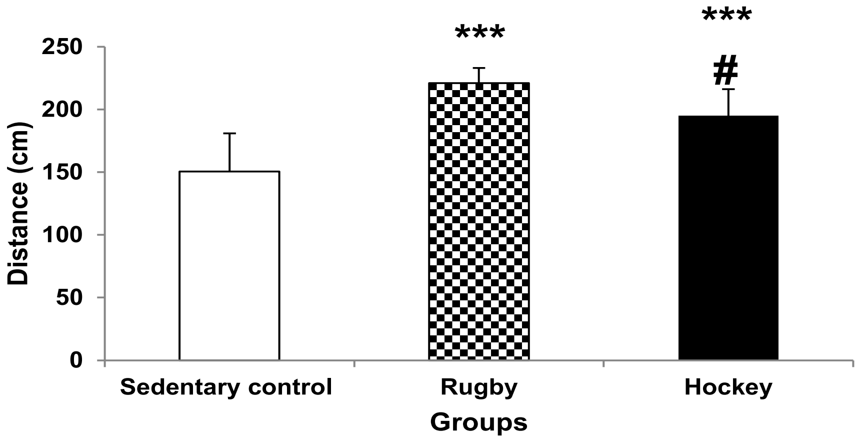

Figure 1: Standing long jump distance in the rugby, hockey and sedentary control groups
****, (p<0.001); significantly different from sedentary control group*
#, (p<0.05); significantly different from rugby group

Agility

Rugby and hockey groups showed significantly ($p<0.001$) higher agility compared to the sedentary control group (Fig. 2). The score from the Illinois agility test for the control, rugby and hockey groups were 19.7(1.7)s, 16.6(0.7)s and17.1 (0.7)s respectively (Fig. 2).

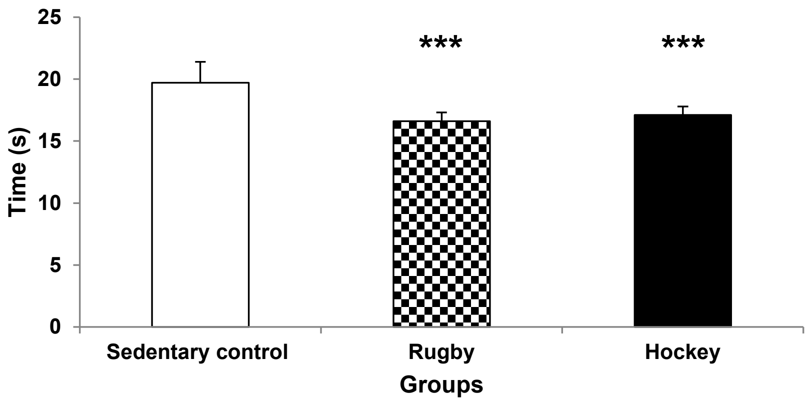

Figure 2: Mean agility time via Illinois agility test in the rugby, hockey and sedentary control groups
****, (p<0.001); significantly different from sedentary control group*

Aerobic Capacity (Predicted VO_{2max})

Rugby and hockey groups showed significantly ($p<0.001$) higher aerobic capacity compared to the sedentary group, while the rugby group also showed significantly ($p<0.001$) higher aerobic capacity compared to the hockey group (Fig. 3). The score from the aerobic capacity (predicted VO_{2max}) test for the sedentary, rugby and hockey groups were 29.7(4.0)mL/kg/min, 50.7 (2.3)mL/kg/min and 39.9 (5.1)mL/kg/min respectively.

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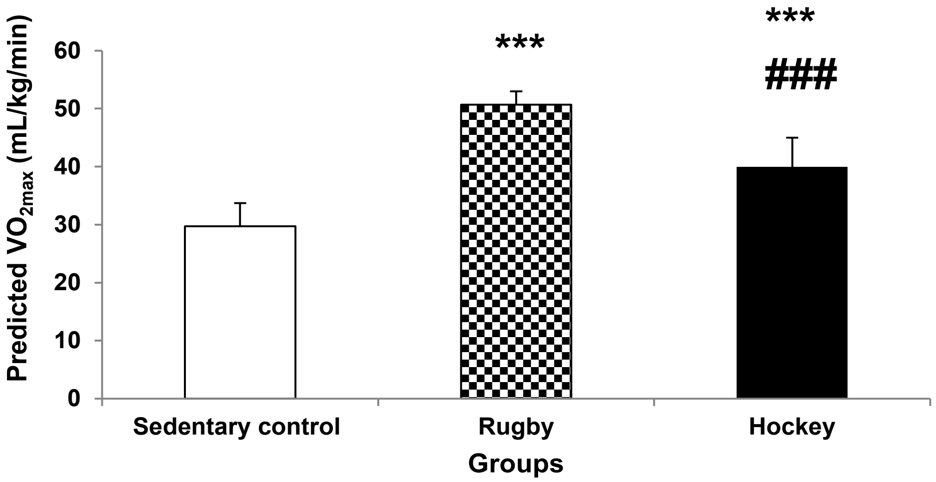

Figure 3: Aerobic capacity (predicted VO_{2max}) in the rugby, hockey and sedentary control groups
****, p<0.001; significantly different from sedentary control group*
###, p<0.001; significantly different from rugby group

Wingate Anaerobic Capacity

Both rugby and hockey groups had significantly higher mean power (MP) compared to the sedentary group at p values of <0.001 and <0.01 respectively. The score from the mean power (MP) for the sedentary, rugby and hockey groups were 334.0(93.3) W, 479.1 (50.2) W and 463.5(74.8) W respectively (Table 3).

In addition, the rugby and hockey groups also showed significantly higher anaerobic capacity compared to the sedentary group at p values of <0.01 and <0.05 respectively. The score from the anaerobic capacity (AC) for the sedentary, rugby and hockey groups were 6.4 (1.4) W/kg, 8.3 (0.7) W/kg and 7.9 (1.3) W/kg respectively. However, there were no significant differences in peak power (PP), anaerobic power (AP) and fatigue index (FI) among the three groups.

Table 3: Wingate anaerobic capacity in rugby, hockey and sedentary control groups

Groups	Sedentary (n=10)	Rugby (n=10)	Hockey (n=10)
Mean Power (Watt)	334.0 (93.3)	**479.1 (50.2)*****	**463.5 (74.8)****
Peak Power (Watt)	505.9 (118.4)	594.6 (56.1)	554.6 (242.4)
Anaerobic Capacity (Watt/kg)	6.4 (1.4)	**8.3 (0.7)****	**7.9 (1.3)***
Anaerobic Power (Watt/kg)	9.8 (1.6)	10.3 (1.2)	10.5 (1.9)
Fatigue Index (Watt/sec)	14.1 (4.9)	12.7 (5.4)	18.0 (5.6)

** p<0.05, **, p<0.01, ***, p<0.001; significantly different from sedentary control group*

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DISCUSSION

In the present study, it was found that there were no significant differences between all groups in terms of body height, body weight, body mass index (BMI), body fat percentage (%BF) and fat free mass among rugby, hockey, and sedentary control groups (Table 1). This finding was not consistent with a previous study carried out by Bell (1979) in a group of second-class rugby union football players and the data from Ohya *et al.* (2015). Bell (1979) reported that rugby union players ought to have larger lean body mass in order to produce better properties of inertia and momentum and the more effective impact at or during contact. Ohya *et al*. (2015) reported that lean body weight of the Japanese elite female rugby players was significantly higher than the elite female field hockey players. Hence, our current findings of no significant differences in fat free mass among the three groups could be attributed to the differences in gender, age, level of competition and different types of training when compared to the participants of the other two studies mentioned.

According to Baljinder *et al.* (2015), muscular strength is the ability to produce maximal force, which is considered a basic motor ability and contributes to high performance in most physical activities and sports for prevention of injury while muscular power is the product of muscular force and velocity, or as an instantaneous value during a given movement. The capacity to rapidly generate high levels of muscular force is a key characteristic of successful rugby league players. Muscular strength in the rugby group was significantly higher compared to the sedentary group in the present study (Table 2). The higher muscular strength in the rugby group was most probably attributed to their physical training as muscular strength is a vital attribute of rugby to resist the large forces generated by the opposing team. Muscular strength is essential for rugby forwards to effectively perform activities such as scrummaging, mauling, tackling, lifting, pushing and pulling opponents during a match (Warrington *et al*., 2001; Mier *et al.*, 2001).

The present study found that the rugby and hockey groups showed significantly higher leg power compared to the sedentary group (Figure 1). This finding implied that both rugby and hockey training could enhance the leg explosive power of the players compared to sedentary individuals. In addition, the notable finding in the present study was that the rugby group showed a significantly higher explosive leg power compared to the hockey group. This may probably be due to the repeated movements of jumping and tackling during training in rugby that allow the players to jump further than the hockey group. Hence, the different techniques, skills, and training patterns may contribute to the higher leg power in the rugby group compared to the hockey group. In addition, Ohya *et al.* (2015) also reported that the countermovement jump distance achieved by the women's rugby seven players were further than the field hockey players. They also mentioned that the capacity to rapidly generate high levels of muscular force was one of the key characteristics of successful rugby players.

Gabbett (2002a) study showed that the relative difference in muscular power between the junior and senior rugby teams of his study was considerably greater than previously reported for other team sport athletes. Their study found a progressive improvement in muscular power scores with increasing age and playing level. In addition, playing experience and body mass also progressively increased from junior players through to senior players. It is likely that the improvement in physiological capacities from junior to senior players reflects a normal adaptation associated with the onset of puberty and moderate increases in age.

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Collectively, the present findings indicated that the physical training programmes conducted by the coaches of the rugby and hockey teams seem to have resulted in a greater muscular strength and power of their players compared to the sedentary controls.

Rugby league players require the ability to rapidly accelerate, decelerate and change direction (Gabett *et al.*, 2008). Agility comprises both perceptual decision-making process and the outcome of this process, a change of direction (COD). It is well established that COD has been considered as a prerequisite in most field sports and an important performance outcome for predicting success (Hachana *et al.,* 2013). Gabbett (2002b) reported a mean Illinois agility times of 17.1 seconds in semi-professional rugby league players. Illinois agility scores for junior (Under 13–19) sub-elite rugby league players are in the range of 17.9–22.0 seconds, with agility improving as the playing level is increased (Gabbett, 2002a). These findings are consistent with most previous studies on other team sports such as Australian football, soccer, and field hockey which have found higher physiological capacities as the playing level increased (Gabbett, 2002a). In the present study, it was found that rugby and hockey groups showed significantly higher agility compared to the sedentary control group (Figure 2). These results imply that engaging in rugby and hockey training enhances one's ability to move quickly and changing direction easily.

In the present study, we found that rugby and hockey groups showed significantly higher aerobic capacity compared to the sedentary group (Figure 3). The findings of the present study were consistent with previous study by Lovell *et al.* (2013), where they reported that there was a significant difference in the absolute VO_{2max} of the upper and lower body of the rugby league players compared to the control group. The main reason for a difference in absolute but not relative VO_{2max} is the larger body mass and in particular muscle mass of the rugby league players compared to the control group. Gabbett and Herzig (2004) reported a mean estimated VO_{2max} scores (48.7–54.6 $mL.kg^{-}1.min^{-1}$) in junior elite rugby league players. Thus, the mean VO_{2max} of 50.7 $mL.kg^{-}1.min^{-1}$ of the rugby group in the present study was comparable with the scores reported above for elite rugby players. The higher aerobic capacity demonstrated in the rugby and hockey groups compared to the sedentary control in the present study was probably attributed to the physical training sessions conducted by their respective coaches.

The finding of the present study found that rugby and hockey groups showed significantly higher mean power (MP) and higher anaerobic capacity (AC) compared to the sedentary control group (Table 3). These findings imply that playing rugby and hockey could elicit higher anaerobic capacity than having sedentary lifestyles. Previous study carried out by Manna *et al.* (2010) investigated the effect of training on anthropometric, physiological and biochemical variables of elite field hockey players found that there was no significant change was noted in anaerobic power of the field hockey players in preparatory phase and competitive phase of training when compared to base line data. This might be due to short duration of the training as well as to the age of the senior elite players. Playing field hockey involves intermittent activities such as short sprinting and casual recovery, therefore a high anaerobic power helps to develop sprint quality of the players.

Lovell *et al*. (2013) reported that semi-elite Rugby League players have well developed absolute anaerobic power compared to the physically active but untrained men. Their finding implies that rugby training could develop anaerobic power better than physically active individuals but untrained in sports. Using a Global Positioning System software, it was found that union rugby players covered on average 6,953 m during play (83 minutes). Of this distance, 11% (740 m) was spent on high-intensity running, and sprinting (Cunniffe *et al.*, 2009). Furthermore, Duthie *et al*. (2003) found that forwards appear to be able to produce higher absolute peak and mean power outputs across a range (7–40 seconds) compared with the backs. They also found that players who have the capability to produce high power outputs also tend to have the greatest fatigue tolerance during tests of moderate (30 seconds) duration.

The present study found that both rugby and hockey groups showed significantly higher Wingate mean power and anaerobic capacity compared to the sedentary control group respectively. Kalinski *et al.* (2002) observed that both relative and absolute peak power values achieved for elite athletes of basketball, handball, rugby, and volleyball were similar. Whereas the rugby and basketball players attained the largest absolute peak power values, their absolute peak power values displayed an inverse relationship to body mass. They observed that both relative and absolute peak power of the basketball, volleyball, handball, and rugby athletes in this study were exceedingly higher than for those anaerobic potentials reported for apparently healthy, untrained males. They also observed for both relative and absolute mean power that values achieved for elite athletes of basketball, handball, and rugby were similar. Therefore, it can be concluded that playing rugby and hockey can enhances one's anaerobic capacity compared to sedentary individuals as observed in Kalinski *et al.* (2002) and the present study. The differences in findings between present and previous studies may be due to differences in ethnicities such as Malays, Indians, Chinese, Africans, Australians and Japanese as well as age, training duration, level of competition and many more.

CONCLUSION

Data from the present study demonstrated that involvement in rugby and hockey physical training has resulted in a higher physical fitness level compared to the sedentary counterparts. In addition, the results have also shown that rugby group was superior in some of the fitness components compared to the hockey group. This finding could be due to differences and nature of the training programmes that both the teams went through.

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The findings obtained from this study provides scientific evidence that physical training in rugby and hockey elicited increased physical fitness components among the players compared to their sedentary counter-parts. Thus, participation in sports is very much encouraged among the sedentary individuals to eliminate some of the risk factors associated with non-communicable diseases.

In addition, there are no ethical or financial issues, conflicts of interests related to this study.

We also agree to submit evidence of Ethical Approval by the Human Research Ethics Committee of USM for this study if required.

Conflict of interest

All the authors declare that there is no conflict of interest.

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