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Factors associated with aerobic and anaerobic capacities in boy adolescent hill tribe collective sports in Thailand

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Abstract

Capacity for both aerobic and anaerobic exercise is crucial for athletes including young adolescents. In northern and western Thai hill tribes, athletes may have different body compositions and capacity from lowlanders. This study aimed to evaluate predictors of aerobic and anaerobic capacity in adolescent hill tribe collective school sports. This cross-sectional study enrolled hill tribe collective boys, aged between 13 and 17 years, who had at least two years' experience in the school sports program and agreed to participate. Body compositions and physical performance were recorded. Factors associated with maximum volume of O_2 ($\dot{V}O_2$ max) and a 20-m sprint test were executed by linear regression analysis. During the study period, 37 boys from hill tribes met the study criteria. Three factors were independently associated with $\dot{V}O_2$ max, namely the ball throw, upper extremity response time, and an agility test. The first factor had an adjusted coefficient of 2.74 ($p = 0.011$), while the latter two factors had negative adjusted coefficients of -135.41 and -3.50 ($p < 0.001$ for both factors). For the 20-m sprint test, there were three predictive factors: fat mass, the agility test, and the standing high jump. The adjusted coefficients of these factors were 0.01, 0.14, and -0.02, respectively (p values = 0.02, < 0.001, and 0.001). Aerobic capacity may be associated with the ball throw, upper extremity response time, and the agility test, while low fat mass, short agility time, and raising the standing high jump may increase anaerobic capacity among adolescent hill tribe athletes.

Keywords: Ball throw, Fat mass, Agility, Cardiorespiratory fitness, Physical fitness

1. Introduction

Exercise is crucial for children's development. A systematic review reported that school-age children should perform moderate physical activity for 60 min daily [1]. This exercise reduced by 51% the risk of obesity, which may lead to future coronary artery disease in adults [2,3]. Exercise has also been shown to reduce both systolic and diastolic blood pressure with beta coefficients of -0.06 and -0.02 for moderate to vigorous exercise [4]. Regarding types of exercise, both aerobic and anaerobic exercise can control non-esterified fatty acids [NEFA] that become more harmful as we age [5]. Anaerobic exercise also showed significantly lower glycated haemoglobin (HbA1C) from 8.2% to 6.8% less in children with type 1 diabetes [6]. Physical inactivity may also lead to obesity, sleep apnea, and cardiovascular diseases [7–12].

High altitude natives may have different functional capacities from lowlanders. One study found that those living at altitudes between 2,500 and 5,000 m had significantly higher $\dot{V}O_2$ max than lowlanders [13].

Additionally, high altitude natives may have high oxygen saturation during hypoxic exercise or anaerobic exercise [14]. Predictors of both aerobic and anaerobic capacity in children or young adults was body composition [3,15–17]. Muscle mass percentage was significantly associated with $\dot{V}O_2$ max in adolescents with a beta coefficient of 0.63 [16]. Limited data exist on predictors of aerobic and anaerobic capacity in hill tribe sports other than body composition. Additionally, hill tribe athletes may have different functional capacities. Therefore, this study aimed to evaluate if any other factors were associated with both aerobic and anaerobic capacity in hill tribe sports participants.

2. Materials and methods

This was a cross-sectional study with the following inclusion criteria. First, those included for the sample belonged to one of the local hill tribe collectives (Akak, Lahu, or Chinese Hung tribes. They had to be boys who were born and raised locally, and now were living and playing on a sports team at high altitude. At the time of their enrollment in the study, the boys were between 13 and 17 years old and had participated in a team sport at school for at least two years and had agreed to participate in the research. Those who were unable to move normally were excluded from the study. The eligible participants were randomly selected from the school's enrollment list by using a simple random sampling method. The study period was between June and October 2019. The study protocol was approved by the ethics committee of the Mae Fah Luang University, Chiang Rai, Thailand (REH-62312) in compliance with the Helsinki Declaration of 1964.

Eligible participants were instructed on the study protocol and asked to a_{vo}id strenuous activity and alcohol consumption for 24 hours prior to the testing date. The experiment was performed during the day and began with a meeting to ensure that the testing protocol was understood and agreed upon by each participant. Then, eligible participants underwent body composition measurement, which comprised each person's weight, height, basal metabolic rate, body fat mass, muscle mass, and mineral mass. These measurements were registered by a body composition analyzer machine (Inbody 270, Inbody Co., Ltd., Seoul, Korea). The measurements were performed by trained sport scientists.

Afterward, physical performance was measured in a sequence of $\dot{V}O_2$ max test, standing high test, a southeast missouri (SEMO) agility test, a 20-m sprint, and a response time test. The 15-stage Yo-Yo intermittent test was used to determine the boys'' indirect $\dot{V}O_2$ max. This test consists of repeated 2 to 20 shuttle lines performed between the start, turn, and end point by the growing sound of a beep controlled by a recorder. There is another disc 5 meters behind the starting point where the participants took a brief break before resuming at the sound of the next beep. Each lap of the 20-m course required the participant to run faster. If the participant failed to cross the finish line before two beeps sounded, his test was over. Miles were tracked, and $\dot{V}O_2$ max was calculated using the following formula: ($\dot{V}O_2$ max (mL/min/kg) = mileage of the test x 0.0136 + 45.3) [18,19].

All participants then performed the vertical jump test to evaluate leg power. This protocol began in the standing position. The participant then stood next to a wall and jumped vertically with both arms and legs assisting to project him upward to reach the top of the wall [20]. Next, the SEMO agility test was used to assess the general agility of the body in operating movement forward, backward, and sideways. Cones were arranged in a square pattern. When the signal sounded, participants had to move in the standard pattern as directed and then return to the starting position as quickly as possible [21].

Using Fitlight equipment, the response time was used to evaluate upper limb reaction (Fitlight Corp, Miami, FL, USA). The Fitlight system is made up of eight LED light sensors that are controlled by a tablet computer and specific software. The built-in force sensor detects compression data and records the time between the appearance of the light and the touch response. The location of the light sensor was described in a previous study [22]. To take the test, participants were instructed to tap the light with their hand as quickly as they could in response to the red light, which appeared on the disc in a random order.

Statistical analyses. Descriptive statistics were used to compute the mean (SD) of each variable. The primary outcomes of this study were $\dot{V}O_2$ max, an indicator of aerobic exercise, and the 20-m sprint test, an indicator of anaerobic exercise. Factors associated with $\dot{V}O_2$ max and the 20-m sprint test were executed by linear regression analysis. A univariate linear regression analysis was performed to calculate unadjusted coefficients with a *p* value. Factors with a *p* value by univariate linear regression analysis of less than 0.20 were put into the subsequent multivariate linear regression analysis in a stepwise manner. The models were checked for distributional assumptions, including residual normality, by the Shapiro–Wilk test, for heteroskedasticity by the Breusch–Pagan test, and for multicollinearity by the variance inflation factor (VIF). Both the residual test and heteroskedasticity were normally distributed, while the VIF values of each factor were less than 10. Results were reported as unadjusted, adjusted coefficients, and *p* values. All statistical analyses were performed using STATA software version 10.1 (College Station, TX, USA).

3. Results

During the study period, 37 boys practicing sports at a hill tribe collective school met the study criteria and agreed to participate in the research. The eligible participants were playing school sports in soccer, basketball, or volleyball. Baseline characteristics and physical performance of the participants are shown in Table 1. The average age (SD) of participants was 14.7 (2.04) years with an average (SD) basal metabolic rate of 1,441 (239.34) kcal. The average $\dot{V}O_2$ max and 20-m sprint test were 39.65 (SD 6.83) mL/(kg·min) and 3.59 (SD 0.37) seconds, respectively.

Table 1 Baseline characters and physical performances in Hill Tribe youth collective sports (n = 37).

Factors	Mean ± SD
Age (years)	14.67 ± 2.04
Weight (kg)	59.66 ± 18.30
Height (cm)	164.37 ± 17.76
Basal metabolic rate (kcal)	1,441.08 ± 239.34
Body mass index (kg/m^2)	21.26 ± 4.67
Body fat mass (kg)	9.60 ± 9.42
Body fat (%)	15.52 ± 9.13
Muscle mass (kg)	28.21 ± 6.30
Mineral mass (kg)	3.43 ± 0.81
Ball throw (m)	4.85 ± 1.24
Standing height jump (cm)	33.67 ± 7.06
Agility test (s)	12.54 ± 1.20
Response time (ms)	498.24 ± 21.57
$\dot{V}$O2 max (mL/(kg·min)	39.65 ± 6.83
20-m sprint test (s)	3.59 ± 0.37

Note. $\dot{V}$O2 max: maximum volume of O_2.

Five factors remained in the final model predictive of $\dot{V}O_2$ max (Table 2). Of those, three factors were independently associated with $\dot{V}O_2$ max: the ball throw, upper extremity response time, and the agility test. The first factor had an adjusted coefficient of 2.74 (p = 0.011), while the latter two factors had negative adjusted coefficients of -135.41 and -3.50 (p < 0.001 for both factors). The equation for VO_2 max was 155.33-(0.82 x age, years)-(0.09 x weight, kg)+(2.74 x ball throw, m)-135.41(upper extremity response time, ms)-(3.50 x agility test, s). The Z-score (or standard score) for the residual normality test of the model was -0.405 (p = 0.657), while the Chi square for the heteroskedasticity was 0.40 (p = 0.526), indicating normal distribution of the model. The VIF scores of each factor in the model were less than 10.

Table 2 factors associated with maximum volume of O_2 ($\dot{V}$O2 max) level in Hill Tribe youth collective sports.

Factors	Unadjusted coefficient (95% CI)	*p* value	Adjusted coefficient (95% CI)	*p* value
Age, years	-0.13 (-1.28, 1.02)	0.823	-0.82 (-1.74, 0.10)	0.078
Weight, kg	-0.06 (-0.18, 0.07)	0.361	-0.09 (-0.23, -0.05)	0.186
Ball throw, m	0.08 (-1.81, 1.90)	0.934	2.74 (0.69, 4.80)	0.011
Upper extremity response time, ms	-154.44 (-249.46, -59.42)	0.002	-135.41 (-205.88, -64.93)	< 0.001
Agility test, s	-3.60 (-5.11, -2.09)	< 0.001	-3.50 (-4.88, -2.14)	< 0.001
Constant	NA		155.33 (116.43, 194.23)	< 0.001

Note. CI: confidence interval; NA: not applicable.

For the 20-m sprint test, three factors remained in the final model: fat mass, the agility test, and the standing high jump (Table 3). The adjusted coefficients of these factors were 0.01, 0.14, and -0.02, respectively (p values = 0.02, < 0.001, and 0.001). The equation for the 20-m sprint test was 2.31+(0.01 x fat mass, kg)-(0.02 x standing high jump, cm)+0.14(agility test, s). The Z-score for the residual normality test of the model was -0.382 (p =

0.648), while the Chi square for the heteroskedasticity was 2.34 (p = 0.126) indicating normal distribution of the model. The VIF scores of each factor in the model were less than 10.

Table 3 factors associated with 20-m sprint test in Hill Tribe youth collective sports.

Factors	Unadjusted coefficient (95% CI)	p value	Adjusted coefficient (95% CI)	p value
Fat mass, kg	0.03 (0.02, 0.04)	< 0.001	0.01 (0.005, 0.02)	0.002
Standing height jump, cm	-0.03 (-0.05, -0.02)	< 0.001	-0.02 (-0.03, -0.01)	0.001
Agility test, s	0.24 (0.18, 0.31)	< 0.001	0.14 (0.07, 0.20)	< 0.001
Constant	NA		2.31 (1.45, 3.17)	< 0.001

Note. CI: confidence interval; NA: not applicable.

4. Discussion

This study found that physical performance factors were mostly independently associated with aerobic and anaerobic capacity in young hill tribe collective school athletes. Only fat mass, a body composition, was a significant predictor for anaerobic capacity (Tables 2 and 3).

Even though two factors related to baseline character and body composition remained in the final model for aerobic capacity – age and weight (Table 2) – they were not statistically significant. Only physical performance was associated with aerobic capacity (Table 2). A previous study found a similarly positive correlation between $\dot{V}O_2$ max and muscle strength of upper extremities even in young sedentary females [23]. Response time was also previously shown to be negatively related with $\dot{V}O_2$ max, with a Pearson correlation of -0.497 (p value < 0.01) [24]. Even though a previous study did not find a significant correlation between agility and $\dot{V}O_2$ max, this study found negative correlations of these factors [25]. These differences may be due to it being a different study population. The previous study was conducted among teenage players of badminton, a sport that may involve more anaerobic exercise resulting in nonsignificant correlations. The other two studies found that agility was negatively correlated with the $\dot{V}O_2$ max with the coefficients of -0.734 (p < 0.001) and -0.834 (p = 0.003) [26,27]. Both of these studies were conducted among football or soccer players, as in this study.

Both body composition and physical performance were independently associated with anaerobic capacity (Table 3). As previously reported, fat mass positively correlated with sprint time (r = 0.50), while countermovement jump was negatively associated with 20-m sprint time (r = -0.61) [28,29]. Several studies showed a positive correlation between anaerobic capacity and agility, with the Pearson correlations ranging between 0.59 and 0.68 (p < 0.05) [29,30].

Our study had some limitations. First, only boy athletes agreed to participate. Further studies with female hill tribe collective sports players may be needed as it might provide diversity between the sexes. However, note that the results of this study may be applied in other countries with students living and playing at the same mountain level as in our study in Thailand. Due to the small sample sizes in each tribe, a predictive model for each tribe or for each sport was not reported here. Second, other physical performance tests or treatments may not have been studied. Finally, the outcome for anaerobic capacity in this study was the 20-m sprint test; another test may have only a 10-m distance. Note that parameters in this study were performed in a short period of time as were the outcomes. Therefore, further studies may be needed to confirm the results of this study or expand the outcomes over a longer period. Additionally, the outcomes in this study were measured indirectly. Further studies with physical performance tests may be required.

5. Conclusion

The long ball throw, shorter upper extremity response time, and shorter agility time were associated with $\dot{V}O_2$ max, while low fat mass, short agility time, and increasingly more challenging standing high jumps were associated with the 20-m sprint test in adolescent hill tribe collective sports participants.

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