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# The correlation between anthropometric measures, $VO_2$max, agility with musculoskeletal injury among adolescents badminton players: A pilot study

**Galih Yogi Handaru, Nawanto Agung Prastowo and Ignatio Rika Haryono**

**Abstract**
Endurance and agility support badminton performance. Low endurance and agility are associated with an injury. This study investigated the relationship between endurance, agility, and injury in badminton players. This study was a cross-sectional study involved badminton athletes (n = 26). $VO_{2max}$ was measured by the bleep test, and agility was evaluated by Badminton Agility Test (BAT). Musculoskeletal injury profile was recorded by physical examination and questionnaire. Data were processed on SPSS, and the data were analyzed statistically using Spearman or Pearson correlation test. There is a strong correlation between VO2max and musculoskeletal injury ($p<0.01$, r=0.72). There is a moderate correlation between agility and musculoskeletal injury ($p<0.01$, r=0.69). Lower extremities injury dominated the musculoskeletal injury. We conclude that there is a significant correlation between musculoskeletal injury with $VO_2$max, and with agility.

**Keywords:** $VO_2$max, agility, musculoskeletal injury, adolescent badminton athletes

## 1. Introduction

Badminton is the most popular sport in Indonesia due to it is the only sport that has presented an Olympic medal gold so far. Badminton has developed since it was introduced in the 18th century. Since then, the way to play badminton has been changing when the rally point regulation was applied. The players tend to play more offensive to collect points and win. This creates badminton becomes more explosive and more intense sports compared to before [1]. Playing badminton this such way demands advance power, strength, speed, agility, and endurance and causes the muscles to work harder [2]. This leaves the badminton players exposed more to injury.

Muscle injuries in badminton have been reported. Due to its characteristics of the game, injury in badminton is usually overuse and mostly located in more active sites such as shoulders, legs, and ankles [3-5]. Musculoskeletal injuries such as a sprain, strain, and range of movement disorders are reported commonly found in badminton athletes [3, 4]. However, more recent reports are needed to obtain possible different characteristics of the injury and some related factors.

Maximum oxygen capacity ($VO_{2max}$) and agility are the two-component of physical fitness required to succeed in badminton. High $VO_{2max}$ is needed to ensure a sufficient oxygen supply so that players can play consistently during a very long game. Badminton players also need advanced agility to change body directions and movements quickly and effectively to pick up the shuttlecock and cover the field [6]. The previous studies reported that there was an association between low physical fitness and injury. A study by Hootman demonstrated that cardiorespiratory fitness had an association with the risk of musculoskeletal injuries [7]. A systematic review by Lisman concluded that cardiorespiratory endurance was included as a risk factor for muscle injury [8]. The association between agility and injury is also reported. Liu *et al*. Stated that agility could describe the risk of injuries in hockey, especially for non-contact injuries [9]. A study by Afsharnezhad in football players indicated that agility has a relationship with the injury, especially with muscle cramp [10].

Sport development usually starts at an early age. Thousands of children and teenagers engage in badminton clubs.

They may undergo an intense training program that increases the possibility of having an injury. This study aimed to investigate the association between $VO_{2max}$ and agility with injury in adolescent badminton players.

## 2. Material and Methods

1. This cross-sectional study was conducted in a badminton club focusing on training teenagers aged 12-18 years in August 2019. Thirty-five badminton players participated the study (14 female, 21 male). Permission was obtained through the club chairman and coaches. Athletes signed informed consent following an explanation. Ethical clearance was issued by the Ethics Commission of Atma Jaya (Number: 37/08/KEP-FKUAJ/2019).
2. Subjects filled their data and musculoskeletal complaints in questionnaire sheets. Subjects described the musculoskeletal complaint and location of the injured area in the past one year. A physical examination was performed to confirm the possible diagnosis of muscle injury. Height and weight were measured using a standard procedure. BMI was obtained from the formula of weight (kg) divided by height square (m).

### 2.1 $VO_{2\ max}$ and agility measurements

The $VO_{2\ max}$ was measured indoor using the Bleep test or multi-stage fitness test (MSFT). The subjects were asked to run a 20-meter back and forth while adjusting the running pace according to the beep from a CD recording. The athletes must reach the shuttle before the beep. The test was considered complete if the athletes were not able to reach the shuttle before the beep. They were allowed to attempt two more shuttles to adjust the pace before withdrawn. The examiner recorded the level and number of shuttles at the level completed when they withdrew. The $VO_2$ max was calculated using the MSFT table based on the level and shuttle completed by examinees.

The agility was measured using a badminton-specific movement agility tests (BSMA). The test was performed on the badminton court. The examinees stand at the center of the half side of the court. Six cones were placed in six locations; front left and right corners, back left and right corners, and left and right sides just on the field lines (Figure 1). The examinees were asked to run and to touch each cone as fast as possible and back to the center before touch the other cone. The order of the test direction was front left corner, front right corner, left side, right side, back left corner, and back right corner. The result was the time duration required to complete the test, from the start until return to the center position.

### 2.2 Statistics methods

The numerical data are presented as mean ± standard deviation (SD) while nominal data as frequency and percent. The normality of the data was analyzed using the Shapiro-Wilk test. A comparison of the variables between groups was analyzed using an independent t-test or Mann-Whitney test. A Chi-square test was used to examine the association between gender and injury. The correlation between injury and variables was tested using the Pearson Test or Spearman Test. The p-value of <0.05 was considered significant. Statistical analysis was computed using a Statistical Package for Social Sciences (SPSS) version 17.

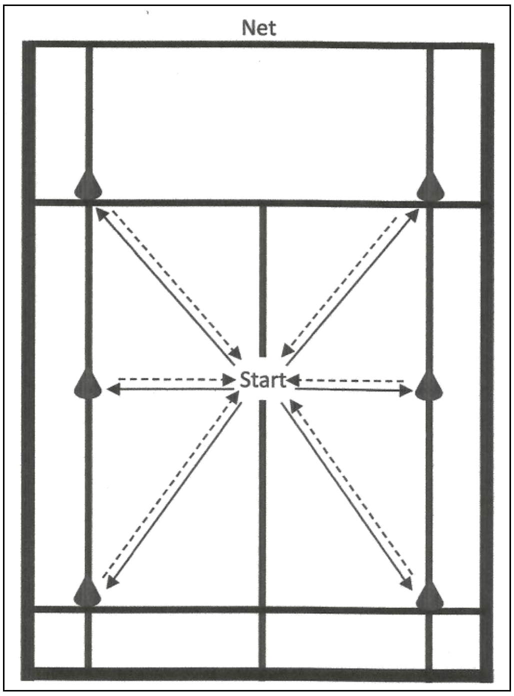


**Fig 1:** Movement patterns of badminton-specific movement agility (BSMA) testing

## 3. Results

The characteristics of the subjects were presented in Table 1. There was a significant difference in height, weight, $VO_{2\ max}$, and agility between gender. Male subjects were taller & heavier and had greater $VO_{2\ max}$ and better agility (all *p*<0.01). Twenty-one subjects (60%) reported suffering from musculoskeletal injury (8 female/22.9%, 13 male/37,1%). Musculoskeletal injury shows no association with gender (p=0.53).

**Table 1:** Subjects' characteristics

| Variables | Overall | Female (n=14) | Male (n=21) | *p* |
|---|---|---|---|---|
| Age (years) | 14.8±1.3 | 14.4±1.1 | 15.0±1.4 | 0.13 |
| Height (cm) | 164.3±6.2 | 159.7±5.1 | 167.4±548 | <0.01 |
| Weight (kg) | 56.8±6.8 | 52.7±4.6 | 59.5±6.7 | <0.01 |
| BMI (kg/m$^2$) | 21.0±1.6 | 20.1±1.4 | 21.2±1.7 | 0.35 |
| $VO_{2max}$ (ml/kg/min) | 45.5±6.8 | 39.6±5.6 | 49.4±4.2 | <0.01 |
| Agility (seconds) | 12.7±1.3 | 13.6±1.1 | 12.1±1.0 | <0.01 |
| Injury (n) | 21 | 8 | 13 | 0.58 |

The correlation of injury with several variables was analyzed (Table 2). Among those variables, musculoskeletal injury has a strong correlation with agility (r=0.72, *p*<0.01) and moderate correlation with $VO_{2max}$ (r=0.69, *p*<0.01). In contrast, other variables showed no correlation with injury and to have a negative correlation.

**Table 2:** The correlation between injury and variables

| Injury | Height | Weight | BMI | Agility | $VO_2$max |
|---|---|---|---|---|---|
| r | -0.04 | -0.08 | -0.06 | 0.72 | -0.69 |
| *p* | 0.82 | 0.66 | 0.72 | <0.01 | <0.01 |

Twenty-three injuries are reported (two subjects have two injuries). The lower limbs have more injury (14 cases/60.9%) compared to upper limbs (7/30.4%) and trunk (2/8.7%) (Table 3). Shoulder pain is the most common complaint in the upper limbs (12%) with a possible diagnosis are impingement syndrome and rotator cuff tendinitis. One subject complained of limited ROM of his elbow without an apparent cause. Pain on the lateral ankle is the most complaint in the lower limbs (20%) with a possible diagnosis are lateral ankle sprain, all on the right side. Three cases are diagnosed as Osgood Schlatter disease as they complained of a painful lump on the patellar tendon insertion at the top of the tibia muscle.

**Table 3:** Injured body area and possible diagnosis

| Body area | Complaint | Frequency (%) | Possible diagnosis |
|---|---|---|---|
| Upper extremity | Shoulder pain | 3 (12%) | Impingement syndrome, rotator cuff tendinitis |
| | Upper arm pain | 1 (8%) | Biceps strain |
| | Decrease ROM of elbow | 1 (4%) | Unclassified |
| | Hand joint pain | 2 (8%) | Wrist sprain |
| Trunk | Lower back pain | 2 (8%) | Back muscle strain |
| Lower extremity | Knee pain | 3 (12%) | Patellar femoral pain syndrome, ligament sprain |
| | Thigh pain | 1 (8%) | Hamstring strain |
| | Painful lump below knee | 3 (12%) | Osgood Schlatter diseases |
| | Lateral ankle pain | 5 (20%) | Lateral ankle sprain |
| | Calf pain | 1 (4%) | Gasctrocnemius strain |
| | Plantar foot pain | 1 (4%) | Plantar fasciitis |

## 4. Discussion

A part of our findings may add to the previous studies by determining the association between anthropometric measures, agility, and VO2 max, and injury [9, 11]. The agility is correlated positively with a musculoskeletal injury, even with a mild degree was evident in this study. However, neither anthropometric measures nor $VO_2$max has a correlation with a muscle injury. More injuries at lower limbs were also reported by previous studies [12, 13]. Approximately 61% of injuries in our study involve the lower limbs.

Agility is correlated with musculoskeletal injury in badminton players with a moderate positive degree. The correlation between agility and injury incidence is in agreement with prior studies. Liu *et al*. reported an association between agility and injures in hockey players and demonstrate that agility is a useful screening tool to predict future injury [9]. However, the evidence for this association is sufficient [11]. To our knowledge, this study is the first reporting the correlation between agility and injury in badminton. A prior study in badminton players reported a link between agility and lower limb strength [14]. But, this result did not explain the associations between agility and injury directly. The essential role of agility in injury has been described by Lyle. It is stated that non-contact injuries are often obtained from the abrupt deceleration acceleration and sudden changes in directions of movement [15]. Therefore, excellent agility should be achieved to minimize musculoskeletal injury.

Like the previous studies, the recent study found the association between $VO_{2max}$ and muscle injuries. A prior study by Watson *et al*. demonstrated that aerobic fitness could predict injury in adolescents and in collegiate soccer players [16, 17]. A study by Hootman *et al*. also observed that cardiorespiratory fitness had a strong relationship with musculoskeletal injury incidence [18]. Lisman's systematic review indicated that cardiorespiratory endurance was included as a risk factor as a musculoskeletal injury [8]. However, a study by Grant *et al*. observed that aerobic fitness was not reliable for musculoskeletal injury in collegiate hockey players [19]. This might occur due to aerobic fitness in hockey players more homogenous or almost no difference between players than in our study. With relatively homogenous between players, the aerobic fitness then have no statistically significant effect on injury.

Our study observed that lower extremity is the most affected site with an injury. Goh *et al*. reported that lower limb injury was the most frequent injury site in Malaysian sports school badminton players, Shariff *et al*. [20] confirmed this result. They observed that most injury sites were at the lower extremity.[21] Badminton is a hand sport. However, badminton has a high demand for legs and feet work to run, lunge, and jump. Besides, lower limbs function to bear bodyweight in all sport and activities. These put the lower limbs as the body region most susceptible to injury.

Some limitations are noted concerning this study. First, a cross-sectional design employed in this study could not directly observe a definite cause-relationship between agility and $VO_2$max with musculoskeletal injury. Which variables come first and affect other variables could not be recognized clearly. Second, information on injury in the past was obtained by a questionnaire. Therefore, the diagnosis could not be established.

## 5. Conclusions

Our findings observed that the agility and $VO_{2max}$ have correlations with musculoskeletal injury in adolescents' badminton players. Lower extremity injury is the most injury. This finding should be interpreted with caution due to some limitations. It is recommended to employ a cohort study to observe the association of injury with agility and $VO_{2max,}$ obviously.

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