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# Risk factors for lower extremity injuries in young badminton players

*Fatores de risco para lesões de extremidade inferior em jovens jogadores de badminton*

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## ABSTRACT

AIMS: Based on the limited evidence available about the intrinsic factors causing lower extremity injuries among Malaysian badminton players, this study was aimed to determine the relationship of demographic and physical characteristics to lower extremity injuries in young badminton players.

METHODS: A cross-sectional study included badminton players between 14 and 24 years of age, categorized into case and control groups. Participants diagnosed with lower limb injuries were designated as cases, and those with no reported injuries were designated as controls. Personal information including demographic data, level of athlete and injury history was collected using a questionnaire. Independent t-test was used to analyze the differences between intrinsic characteristics in cases and controls. Pearson's $\chi^2$ was applied to evaluate the association between risk factors and general lower limb injuries, knee injuries and ankle injuries, with 95% confidence interval (CI). A p value of ≤0.05 was considered significant.

RESULTS: A total of 106 young badminton players (83 males, 23 females) were recruited, of whom 42 participants were allocated as the case group, and 64 participants were allocated as the control group. A total of 60 lower extremity injuries were reported among the 42 players of the case group. The overall mean age of the sample was 18.7±5 years (minimum 14 years and maximum 24 years). Mean age of the participants in the case group was 16.92±2.99 years. The most common injuries reported were ankle joint injuries, followed by knee and hip injuries. Participants of the younger age group (14-19 years old) were found to have a higher risk for lower extremity injures compared to those of the older age group (20-24 years old) (odds ratio [OR], 3.39; 95%CI, 1.15-10.01; p=0.023). Increased true limb length discrepancy was identified among the participants with lower extremity injuries (OR, 4.57, 95%CI, 1.2-17.24; p=0.016) and this discrepancy was strongly associated with ankle injuries (OR, 7.25; 95%CI, 1.85-28.57; p=0.002). There was no significant relationship between lower extremity injuries and gender, limb dominance or Q-angle.

CONCLUSIONS: Lower extremity injuries in young badminton players were predominantly located in ankle and knee joints. Younger age and increase in true limb length discrepancy were identified as risk factors for lower extremity injuries in the study sample.

**KEYWORDS:** ankle injuries; knee injuries; badminton; racquet sports; youths; risk factors.

## RESUMO

OBJETIVOS: Com base na limitada evidência disponível sobre os fatores intrínsecos que causam lesões de extremidade inferior entre os jogadores de badminton da Malásia, este estudo teve como objetivo avaliar as relações de características demográficas e físicas com lesões nas extremidades inferiores em jovens jogadores de badminton.

MÉTODOS: Um estudo transversal incluiu jogadores de badminton entre 14 e 24 anos de idade, categorizados em grupos de casos e controles. Os participantes diagnosticados com lesões dos membros inferiores foram designados como casos, e aqueles sem lesões relatadas foram designados como controles. Informações pessoais, incluindo dados demográficos, nível de atleta e histórico de lesões foram coletadas usando um questionário. O teste t independente foi utilizado para analisar as diferenças entre características intrínsecas em casos e controles. O $\chi^2$ de Pearson foi aplicado para avaliar a associação entre fatores de risco e lesões de membro inferior em geral, lesões no joelho e lesões no tornozelo, com intervalo de confiança (IC) de 95%. Um valor de p ≤0,05 foi considerado como significativo.

RESULTADOS: Um total de 106 jovens jogadores de badminton (83 do gênero masculino e 23 do gênero feminino) foram recrutados, dos quais 42 participantes foram alocados no grupo de casos e 64 participantes foram alocados no grupo controle. Um total de 60 lesões nas extremidades inferiores foram relatadas entre os 42 jogadores do grupo de casos. A média de idade da amostra total foi de 18,7±5 anos (mínima 14 anos e máxima 24 anos). A média de idade dos participantes no grupo de casos foi de 16,92±2,99 anos. As lesões mais comumente relatadas foram as localizadas na articulação do tornozelo, seguidas das lesões de joelho e de quadril. Os participantes da faixa etária mais jovem (14-19 anos de idade) apresentaram maior risco de lesões nas extremidades inferiores em comparação com os de faixa etária mais velha (20-24 anos de idade) (odds ratio [OR], 3.39; 95% CI, 1,15-10,01; p=0,023). Maior discrepância verdadeira no comprimento dos membros inferiores foi identificada entre os participantes com lesões nas extremidades inferiores (OR, 4,57, IC 95%, 1,2-17,24; p=0,016) e esta discrepância foi fortemente associada a lesões no tornozelo (OR, 7,25; IC95%, 1,85 -28,57; p=0,002). Não houve relações significativas entre lesões das extremidades inferiores e gênero, dominância dos membros ou ângulo Q.

CONCLUSÕES: As lesões das extremidades inferiores em jovens jogadores de badminton foram predominantemente localizadas nas articulações do tornozelo e do joelho. A faixa etária mais jovem e o aumento da discrepância verdadeira no comprimento dos membros foram identificados como fatores de risco para lesões das extremidades inferiores na amostra estudada.

**DESCRITORES:** traumatismos do tornozelo; traumatismos do joelho; badminton; esportes com raquete; jovens; fatores de risco.

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## INTRODUCTION

Badminton is a very popular and universally accepted racquet sport played worldwide. According to the Badminton World Federation, there are around 150 million people playing badminton worldwide and about 2000 players take part in international games. Badminton is a high agility sport which requires lunges, jumping, rapid arm movement and quick change of direction from various positions during the racquet swing. It requires players to cross the badminton court to both sides from midcourt to forward and backward to execute the shots. All these movements require high level of agility while flexing and extending lower limb joints (hip, knee and ankle) in a fast manner [1-3].

Competitive badminton players have a high level of technical skill, tactical competence and physical capacity. Furthermore, badminton match requires high intensity intermittent actions within short resting period [4]. Fatigue may affect the neuromuscular control of lower limb, which is susceptible to increase the risk of injuries [5]. Thus, the physical demands of badminton lead to a high risk for upper and lower extremities injuries, which result in decreased ability in performance and work time, and increased medical costs [3, 6]. A retrospective study among Malaysian badminton players reported about 60% of injuries happened when they were younger than 20 years. Most common injuries were due to overuse and involved mainly the knees. Injuries occurred most frequently during training sessions [1]. In 2012, the Games of XXX Olympiad (London Olympic) reported badminton as one of the highest risk games for athletic injury [7]. Other studies showed the majority of injuries among badminton players occurred in lower extremities [8, 9], which might be due to rapid movements required in this game [10].

Currently only limited evidence is available about the relationship between risk factors and lower extremity injuries among Malaysian badminton players [11]. Risk factors for lower limb injuries need to be investigated to help develop appropriate preventive measures. Thus, this study aimed to analyze the relationship of demographic and physical characteristics to lower limb injuries in badminton players.

## METHODS

This research project was approved by the University Ethics Committee of the INTI International University. The study was conducted in accordance with the ethical standards of the 1964 Declaration of Helsinki and its later amendments. Written informed consent was obtained from each participant to ensure the voluntary participation in the study.

Malaysian badminton players between 14 and 24 years of age were recruited for this cross-sectional study. Players with reported injuries were designated as the case group, and players with no reported injuries were designated as the control group. Inclusion criteria for case group were badminton players with age range from 14 to 24 years; regular training at least two sessions in a week with a minimum of two hours of play each session; and incidence of some injury related to the badminton activity within the period of one year. Players who had an incidence of lower extremity injury during other activities within the past one year were excluded from the case group. Inclusion criteria for the control group were badminton players with age range from 14 to 24 years; regular training at least two sessions in a week with minimum of two hour play each session; and no reported injuries.

A personal information questionnaire was developed and validated by experts from the Faculty of Health and Life Sciences, INTI International University, Malaysia. Information checklist was used to collect demographic data such as age, gender, height, weight, skill level, limb dominance, frequency and duration of training, and previous injuries within one-year duration. The chronology of data collection and evaluation procedures is described in a flowchart (**Figure 1**).

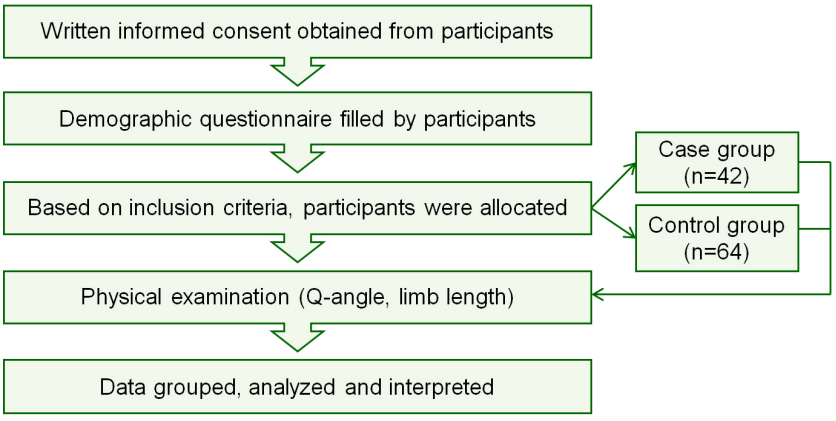


**Figure 1.** Flowchart of data collection procedures.

Physical examinations, including lower extremities length discrepancy and Q-angle measurement were done by the researchers. A measuring tape was used to measure the length discrepancy by true limb length and functional limb length. True limb length was assessed in supine lying position by placing the legs 15 cm apart in parallel to each other with the medial malleolus and anterior superior iliac spine as the reference points [12-15]. Functional limb length was assessed in supine lying position with the legs 15 cm apart in parallel to each other, with the measurement made from the tip of the umbilicus to the bottom of the medial malleolus [14]. The Q-angle measurement was made by using universal goniometer in erect comfortable standing position without shoes, knee straight with quadriceps muscle relaxed and feet facing anteriorly with approximately shoulder apart [16-18]. The first and the second vertical lines were drawn from the anterior superior iliac spine to the midpoint of patella and from the midpoint of patella to the tibial tuberosity respectively. The bisecting angle was measured by placing the fulcrum of the goniometer at the midpoint of patella. Asymmetric Q-angle was measured by comparing the difference between right and left Q-angle and categorized into two groups (difference 0°-3° and difference >3°) [17].

Independent t-test was used to analyze the difference between intrinsic characteristics in cases and controls. Pearson's $\chi^2$ was applied to evaluate the association between risk factors and general lower limb injuries, knee injuries and ankle injuries, with 95% confidence interval (CI). A p value of ≤0.05 was considered significant.

## RESULTS

A total of 106 Malaysian young badminton players (83 males, 23 females) were recruited. Players were from national level (n=4), state level (n=41), district level (n=4), clubs (n=13), high school (n=21) and recreational players (n=23). Forty-two players with reported injuries were included in the case group, and 64 players with no reported injuries were included in the control group.

Data analysis reported the occurrence of 60 lower extremity injuries among the 42 case group players. Ankle joint injury was the most common lower extremity injury (63.3%) amongst the participants (**Table 1**).

The overall mean age of the sample was 18.7±5 years (minimum 14 years and maximum 24 years). A significant difference in the mean age of cases and controls was reported, with 15.98±2.28 years for players with lower extremity injuries and 17.55±3.24 years for non-injured players (p=0.007). No difference in Q-angle and asymmetrical Q-angle was reported between control group participants and case group participants with general lower extremity injuries, knee injuries or ankle injuries (**Table 2**).

**Table 1.** Type of lower extremity injury among the 42 young badminton players allocated as the case group.

| Injury type | n (%) |
|---|---|
| Anterior hip strain | 4 (6.7) |
| Hip adductor strain | 1 (1.7) |
| Anterior knee strain | 14 (23.3) |
| Hamstring strain | 2 (3.3) |
| Anterior cruciate ligament tear | 1 (1.7) |
| Ankle sprain | 29 (48.3) |
| Calf muscle strain | 5 (8.3) |
| Ankle muscle strain | 4 (6.7) |

**Table 2.** Risk factors for lower extremity injuries in young Malaysian badminton players.

| Characteristic | Injured Mean±SD | Non-injured Mean±SD | p value |
|---|---|---|---|
| Age | 15.98±2.28 | 17.55±3.24 | **0.007** |
| General Lower Extremity Injuries | | | |
| Q-angle | 14.15±3.2 | 13.82±2.81 | 0.543 |
| Asymmetric Q-angle | 1.3±0.46 | 1.27±0.45 | 0.674 |
| Knee Injuries | | | |
| Q-Angle | 14.32±3.36 | 13.8±2.81 | 0.531 |
| Asymmetric Q-angle | 1.29±0.47 | 1.27±0.45 | 0.817 |
| Ankle Injuries | | | |
| Q-angle | 14.02±3.15 | 13.82±2.81 | 0.733 |
| Asymmetric Q-angle | 1.29±0.46 | 1.27±0.45 | 0.797 |

SD, standard deviation.

Players aged 14 to 19 years appeared to have higher risk for lower extremity injuries when compared to players aged 20 to 24 years (odds ratio [OR], 3.39; p=0.023). There was no significant association between gender and lower extremity injuries (**Table 3**).

Increased true limb length discrepancy was found to be associated with higher risk for general lower extremity injuries (OR 4.57; p=0.016), while other risk factors such as Q-angle, functional limb length discrepancy and limb dominance were not associated with the occurrence of lower extremity injuries (**Table 3**).

No risk factor was found to be associated specifically with knee injury, as shown in **Table 4**.

True limb length discrepancy >1 cm was identified as a risk factor for ankle injuries (OR, 7.25; 95% CI, 1.85-28.57; p=0.002) (**Table 5**).

**Table 3.** Risk factors for general lower extremity injuries in young Malaysian badminton players.

| Characteristic | Odds ratio | 95%CI | p value |
|---|---|---|---|
| Age (years) | | | |
| 14-19 | 3.39 | **1.15-10.01** | **0.023** |
| 20-24 | 1 | | |
| Gender | | | |
| Male | 1.3 | 0.5-3.41 | 0.592 |
| Female | 1 | | |
| Limb Dominance | | | |
| Yes | 0.85 | 0.21-3.38 | 0.816 |
| No | 1 | | |
| Q-angle (°) | | | 0.447 |
| <10.98 | 1.39 | 0.49-3.95 | 0.534 |
| 10.98-16.98 | 1 | | |
| >16.98 | 1.79 | 0.69-4.63 | 0.229 |
| Q-angle different (°) | | | |
| 0-3 | 1 | | |
| >3 | 1.19 | 0.54-2.59 | 0.671 |
| True Limb Length Discrepancy (cm) | | | |
| Within 1 | 1 | | |
| >1 | 4.57 | **1.2-17.24** | **0.016** |
| Functional limb length discrepancy (cm) | | | |
| Within 1 | 1 | | |
| >1 | 1.07 | 0.21-5.53 | 0.935 |

CI, confidence interval.

**Table 4.** Risk factors for knee injuries in young Malaysian badminton players.

| Characteristic | Odds ratio | 95%CI | p value |
|---|---|---|---|
| Limb Dominance | | | 1 |
| Yes | 0.67 | 0.05-9.19 | 1 |
| No | 1 | | |
| Q-angle (°) | | | 0.161 |
| <11.01 | 2.31 | 0.63-8.51 | 0.202 |
| 11.01-16.85 | 1 | | |
| >16.85 | 3.33 | 0.86-13 | 0.072 |
| Q-angle difference (°) | | | |
| 0-3 | 1 | | |
| >3 | 1.15 | 0.35-3.76 | 0.814 |
| True Limb Length discrepancy (cm) | | | |
| Within 1 | 1 | | |
| >1 | 0.78 | 0.7-0.88 | 1 |
| Functional limb length discrepancy (cm) | | | 1 |
| Within 1 | 1 | | |
| >1 | 0.78 | 0.7-0.88 | 1 |

CI, confidence interval.

**Table 5.** Risk factors for ankle injuries in young Malaysian badminton players.

| Characteristic | Odds ratio | 95% CI | p value |
|---|---|---|---|
| Limb Dominance | | | |
| Yes | 1.46 | 0.25-8.4 | 0.682 |
| No | 1 | | |
| Q-angle (°) | | | 0.827 |
| <10.97 | 1.13 | 0.34-3.81 | 0.844 |
| 10.97-16.83 | 1 | | |
| >16.83 | 1.41 | 0.47-4.22 | 0.542 |
| Q-angle difference (°) | | | |
| 0-3 | 1 | | |
| >3 | 1.13 | 0.46-2.76 | 0.794 |
| True Limb Length discrepancy (cm) | | | |
| Within 1 | 1 | | |
| >1 | 7.25 | 1.85-28.57 | **0.002** |
| Functional limb length discrepancy (cm) | | | |
| Within 1 | 1 | | |
| >1 | 1.74 | 0.33-9.09 | 0.668 |

CI, confidence interval.

## DISCUSSION

This study with young badminton players reported that participants with the lower age range had higher risk of lower extremity injuries. This result is consistent with findings of previous studies, where ankle injuries were mostly reported among the youngest Malaysian badminton players [1, 11]. Higher frequency of injury in younger age groups might have occurred due to lack of skills or lack of experience in badminton sport as similar with previous findings [3, 11]. Increased release of androgen hormone may facilitate increment in muscle strength, speed and muscle mass, but at the same time, it declines coordination temporarily, which may increase the risk of sport injury among young players [19]. Additionally, adolescents have accelerated longitudinal growth of extremities, which may cause change in stress forces on muscle mass and tendons [20] and to contribute for higher chance of lower extremity injuries by overuse and repetitive loading activities [21].

Similar to our findings, previous studies in badminton and recreational athletes have reported that gender difference was not related to the lower extremity injuries [1, 22, 23]. However, gender was associated with chronic ankle instability in young adult sport players; specifically, female players were more prone to injuries [11, 24].

Limb dominance was not found as a risk factor for lower extremity injuries in the present study. This

finding is consistent with the study conducted by Chomiak et al. on soccer players [25]. However, the studies by Faude et al. [26] and Orchard [27] reported a significant association with the dominant leg with lower extremity injuries in soccer players. They also reported that most of the injuries have occurred in the dominant leg among female soccer players [26, 27].

This study found that neither greater Q-angle nor asymmetric Q-angle were risk factors for lower extremity injury in badminton game. In contrast, several research studies [16, 17, 28, 29] evidenced larger Q-angle as one of the risk factors among runners, basketball players and army trainees. A difference of true limb length (1-1.3 cm) is considered normal, while a higher range may result in pathological symptoms [14]. Participants having greater than 1 cm of true limb length discrepancy were found to have more lower extremity injuries in general, especially ankle injuries. Subotnick [30] revealed the existence of pain in the hip, thigh, and iliotibial band during the presence of limb length discrepancy. However, the author did not specify whether the pain was due to true length or functional length discrepancy. In addition, the study highlighted the higher risk of injury in shorter limb compared to longer limb [30].

This study had limitations in capturing the information on the number of rallies, number of steps taken, and nature of cross-court movements, which is feasible by video capture and coordination assessment to find the temporary decline among young players.

In conclusion, this study reported non-existence of intrinsic risk factors such as gender, limb dominance, increased functional limb length discrepancy and Q-angle for lower extremity injuries among young Malaysian badminton players. Lower extremity injuries in young badminton players were predominantly located in ankle and knee joints. Younger age was a risk factor for lower extremity injuries in the study sample. Association between increased true limb length discrepancy and lower extremity injuries, especially ankle injuries, was also identified. Investigating multiple risk factors for badminton injuries may help to improve the injury prevention strategies.

## NOTES

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### Conflicts of interest disclosure

The authors declare no competing interests relevant to the content of this study.

### Authors' contributions

All the authors declare to have made substantial contributions to the conception, or design, or acquisition, or analysis, or interpretation of data; and drafting the work or revising it critically for important intellectual content; and to approve the version to be published.

### Availability of data and responsibility for the results

All the authors declare to have had full access to the available data and they assume full responsibility for the integrity of these results.

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