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Recreational Badminton Players with Chronic Ankle Instability: The Associations between Dynamic Balance and Lower Limb Muscles Power

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Abstract

Background: *Badminton is a universally accepted sports and has increased popularity worldwide. However, the associations between dynamic balance and lower limb muscle power among recreational badminton players with chronic ankle instability (CAI) remained unknown.*

Aim: *To investigate the association between dynamic balance and lower limb (LL) explosive power among recreational badminton players with CAI.*

Methods: *A total of sixty recreational badminton players with CAI were recruited. Star Excursion Balance Test was used to assess the dynamic balance and Sargent Jump test was used to determine the LL explosive power of the participants.*

Results*: There is a small-sized, negative association between dynamic balance and LL explosive power among recreational badminton players with chronic ankle instability (r=-0.288, p<0.05). In*

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a meanwhile, there is an association between dynamic balance with weight (r=-0.433, p<0.05), height (r=-0.537, p<0.05), limb length (r=0.628, p<0.05) and frequency of playing badminton per week (r=-0.307, p<0.05). Also, there is an association between lower limb explosive power with weight (r=0.815, p<0.05), height (r=0.743, p<0.05), BMI (r=0.576, p<0.05), limb length (r=0.713, p<0.05), frequency of badminton per week (r=0.406, p<0.05), and frequency of giving way in the past 6 months (r=-0.546, p<0.05).

Conclusion: *The dynamic balance and LL explosive power in an individual may vary with different anthropometric characteristics. However, the small-sized correlation between dynamic balance and LL explosive power indicates that the rehabilitation of the dynamic balance and explosive power among individuals with CAI may implement independently.*

Keywords: Associations, dynamic balance, lower limb explosive power, recreational badminton players, chronic ankle instability.

BACKGROUND

Chronic Ankle Instability (CAI) is a common consequences after significant lateral ankle sprain in an individual. The failure of implementation of proper training regime and rehabilitation after first ankle sprain may leads to high chance of recurrent ankle sprain. It is estimated that approximately 40% of individuals who experienced a first episode of significant ankle sprain will develop a chronic or long-term ankle dysfunction (Hertel, Braham, Hale, & Olmsted-Kramer, 2006). Individuals with CAI are expected to have a perception of 'giving-way' during their activities of daily living (ADL) such as walking, climbing up and down the stairs, or may even have more episodes during sports. Clinically, patients with recurrent sprain will always has a complaint of extreme inversion injury and special precautions has to be always taken to avoid the symptoms during activities such as walking on uneven surface, playing sports, jumping and hopping.

In badminton, the players require a high agility performance as the badminton game requires lunges, high jump movement, rapid arm movement and fast change of direction from several positions during the game or match. It is a high intensity exercises as it requires high physical ability which mainly focusing on acceleration, deceleration, agility, muscular control as well as power (Sable et al., 2017). Not surprisingly, the most commonest injury in badminton game is the lower limb, and the ankle sprain, with both acute and recurrent was the most frequent type of injury affecting the ankle (Shariff, George, & Ramlan, 2009). In United States, there was more than 10% of the musculoskeletal injuries is the ankle injuries according to the studies of more than 3 million emergency room visited annually (CDC, 2018).

Due to the high incidence of ankle injuries which often leads to chronic ankle instability, this study was to find out the association between dynamic balance and lower limb explosive power in recreational badminton players with chronic ankle instability in order to establish a more proper training programme to reduce the possibility of recurrent ankle sprain. (Box, 2010) reported the dynamic postural control of a person can be altered due to fatigue or chronic ankle instability. Furthermore, (Id et al., 2018) reported that athletes who never been trained and mastered with badminton skills are at higher risks of getting injuries. This can be explained by the quantity and quality of muscles recruitment as well as muscle properties in skilled badminton players being better than unskilled players. Besides, skilled and trained players may have stronger muscles strength compared to untrained players. Hence, this study focused on recreational badminton players with chronic ankle instability in order to figure out the possible correlation resulting in their injuries.

METHODOLOGY

This study used a cross-sectional study design. A total of 60 recreational badminton players from Universiti Tunku Abdul Rahman, Malaysia were recruited by using convenience sampling. Participants from badminton club were randomly invited to voluntarily participate in the study via face to face as well as through social network site. Besides that, participants were recruited from badminton courts around university and they were asked to complete the study in the campus.

The participants for the study were targeted based on standard recommendation by (P. A. Gribble et al., 2014).

- Both genders.
- Participants aged between 18 - 25.
- Had a history of at least 1 significant lateral ankle sprain one year prior.
- Had a history of previously injured ankle joint 'giving way' and/or recurrent sprain or feeling of instability. Specifically, the episodes of giving way must be at least 2 times in the past 6 months.
- Scored Cumberland Ankle Instability Tool (CAIT) <24.
- Recreational badminton players who were playing at least once in a week (Muttalib et al., 2009).

In this research, a questionnaire designed by Hiller et al which is Cumberland Ankle Instability Tool was used to identify the population with chronic ankle instability (Hiller et al., 2006). An email was sent to Elsevier and Copyright Clearance Centre to request permission before using the Cumberland Ankle Instability Tool questionnaire.

There were 9 items in the Cumberland Ankle Instability Tool questionnaire. The participants were required to choose one statement only in each question which best described and most applicable to his or her ankle. The total score was then calculated and those who scores <24 from the questionnaire were qualified in the study.

Besides, a self-designed questionnaire was used in order to get the general information of the participants. The questionnaire consisted of 3 section, namely Section A, Section B and Section C. Section A consisted of questions on the general information of participants (e.g. age, gender). The anthropometric measurements (height and weight) were measured and filled by the researcher. Section B of the questionnaire contained 8 questions which served the purpose of selecting the participants who met the inclusion criteria and excluded those who failed to fulfil the inclusion criteria. The participants were asked to select only one answer in each question. Section C of the questionnaire showcased the results of Star Excursion Balance test and Sargent Jump Test.

Procedure of Body Weight Measurement

1. Participants were to take off their footwear, wallets, handphones or any other things in the pocket that could affect the result before the weight was measured.
2. The weighing machine was set as 'zero' prior to the body weight measurement.
3. After that, the participants were instructed to step onto the centre of the weighing platform with body stand erect, eyes looking forward, both arms relaxed by the sides of the body, and also distribute their body weight equally to both lower limbs.
4. The participants' weight were then read and recorded down by the examiner to the nearest 0.1kg.

Procedure of Body Height Measurement

1. Participants were asked to remove their shoes before standing on the platform attached to the stadiometer.
2. The participants were then instructed to stand in upright position, eyes looking forward, with straighten their back, hip and knee, as well as feet together.
3. The horizontal headpiece of the stadiometer was then adjusted and placed flat on the participant's head.
4. The examiner made sure the eyes to be perpendicular to the marking of the head piece and the height of the participants were recorded with unit nearest to 0.1cm in the data collection sheet.

Procedure of Limb Length Measurement

1. The participants were asked to remove the footwear before the limb length is measured.
2. The participants were then instructed to stand with back against the wall with body in upright position, both arms relaxed at the side of the body, as well as both feet slightly apart.
3. The examiner was then palpated the ASIS and measured the limb length from ASIS to medial malleolus.
4. The reading was then recorded down in the data collection sheet nearest to 0.1cm.

5. The reading was taken 3 times to take the average value.
6. The same procedure was repeated for both side of the lower limbs.

Procedure of Star Excursion Balance Test

1. The participants were asked to wear lightweight clothing and remove their footwear prior to the test.
2. Participants were instructed to stand in the centre of the star, with both hands firmly placed on their hips.
3. When using the right foot as reaching foot, the participants were instructed to stand on their left leg.
4. Then, they were instructed to reach with one foot as far as possible in each direction and lightly touch the line before returning back to the starting position. In a meanwhile, they were reminded not to shift their weight to the right leg.
5. The examiner then used a pencil to mark the spot at which the participants touched the line with their toe.
6. After the participants completed all the eight directions, they were given 1 min break in between to prevent fatigue. They were required to perform total 3 times per leg.
7. The reading was then recorded down with nearest to 0.1cm by the examiner in the data collection sheet.

SEBT performance scores = Average distance in each direction (cm)/leg length *100

Procedure of Sargent Jump Test

1. The participants were required to do 5 minutes warm-up prior to the test to prevent injury.
2. They were then asked to stand beside the wall, with dominant hand at the side of the wall, as well as both feet flat on the ground.
3. Then, they were marked with chalk at the end of their fingertips.
4. They were then asked to reach up as high as possible with one hand and mark the wall with their fingertips. In a meanwhile, they were asked to keep both the legs flat on the floor.
5. After that, from a static position, the participants were asked to jump as high as possible and touch the wall with their

fingertips. During the jump, shuffling or stepping forward was not allowed.

6. The standing reach distance and jump height were then recorded by the examiner in the data collection sheet.
7. The procedure was repeated for 3 times and the average jump height is taken for the power calculation.

Sayers Peak Power Equation, PP = [60.7 x jump height (cm)] + 45.3 weight (kg) -2055 (Sayers et al., 1999)

Upon completion of the data collection, the results of the dynamic balance and Sargent Jump test were disclosed to the participants.

ETHICAL CONSIDERATION

Ethical clearance form was submitted to UTAR Scientific and Ethical Review Committee (SERC) prior to the conduction of the study and the approval was received to progress with the study. A letter of cooperation written from the respective department to the institute where data collection was taken was involved in this study prior to the data collection period. Targeted participants were recruited and the further procedure of the study were only progressed in participants with qualified inclusion criteria. The details of the research study were explained to all participants before conducting the test, which included the purpose of the study, brief procedure, anticipated risk and benefits that could be anticipated from the study. After the brief description of the study, the consent form was given to the participants before participating in the research. They were instructed to read the consent form thoroughly before they fill in their details and sign the form. Personal information of the participants was kept confidential. Ethics was maintained strictly throughout the study.

DISCUSSION

Association of dynamic balance and chronic ankle instability (CAI)

According to the findings, the result shows there is medium, negative correlation between the SEBT composite score and frequency of playing badminton in a week ($r=-0.307$, $p<0.05$). Besides, the scores of

Cumberland Ankle Instability Tool (CAIT) is found to be correlated with frequency of giving way in the past 6 months as well as timing of recurrent ankle sprain by using Spearman Correlation test. The CAIT scores is significantly medium, negative correlation with frequency of giving way in the past 6 months ($r=-0.378$, $p<0.05$). This implies that the participants with higher frequency of giving way will have a lower score of CAIT. In another words, it can be said that participants with severe balance deficit will experience more episodes of giving way as CAIT is positive correlates with dynamic balance.

A study on reliability of CAIT done by (Hiller et al., 2006) has concluded that CAIT scores may predict the risk of recurrent sprain in the population who is having functional ankle instability. Also, those with low score of CAIT are at a higher risk of getting recurrent sprain or more episodes of giving way, and those with high score are less likely to reinjure their ankle. This supports our finding that low CAIT scores is correlates with high episodes of giving way.

Association of lower limb explosive power and chronic ankle instability

At the same time, the result shows us that the frequency of playing badminton weekly has a medium positive correlation with peak power ($r=0.406$, $p<0.05$). This implies that the participants who had higher frequency of playing badminton weekly had a significant greater lower limb peak power. The results of higher peak power in participants who were playing more frequently in badminton is probably due to the muscle adaptation to the badminton-specific movement in a long term. The most applicable and widely-used badminton-specific movement is the vertical jump when doing smashing in badminton game.

A study done by (Andersen, Larsson, Overgaard, & Aagaard, 2007) showed that the badminton players had a higher explosive muscle strength with higher contractile rate of force development than recreational physically active participants. The result was the same even after the recreational physically active participants were given 14 weeks of resistance training, they still achieved the same isometric and slow concentric muscle strength. This finding gives us the inference that badminton players has greater explosive power which may due to a long-term physiological adaptation to the badminton-related movement.

When we look into the correlation between frequency of giving way in the past 6 months and peak power, the result shows that there is a significant strong, negative relationship among these 2 variables, r=-0.546, p<0.05. This implies that the participants with higher frequency of giving way in the past 6 months will have a lower peak power. We suggested that the possible assumption for this result is that the fear of fall or instability when the participants are doing the vertical jump. A study on biomechanics of ankle giving way during landing in subjects with CAI showed that there is high chance of lateral tilt which may lead to lateral shifted of center of pressure (COP) and thus high chance of lateral sprain (Li et al., 2018). Another study also showed that untrained badminton players has a larger impact loading rates when compared to skilled badminton players (Id et al., 2018). Hence, we suggested that with high frequency of giving way, the participants may have a fear of reinjured their ankle and this may lead to withdrawal of certain movements.

Correlation between dynamic balance and lower limb explosive power

The results showed that there is mild negative correlation between dynamic balance and lower limb explosive power (r=-0.288, p<0.05). (Muehlbauer et al., 2012) reported that there was no significant correlation between strength, power as well as balance in elderly population. (Uehlbauer & Ollhofer, 2013) also reported that no correlation found between static and dynamic balance and power. A more recent study by (Muehlbauer et al., 2015) reported that there is small-sized correlations between balance and lower limb muscular strength and power in all aged groups. The contradiction of the studies may due to the population studied was different in all the studies. In addition, the homogeneity of the participants in the study may alter the findings as well. Besides, we predict that the difference in muscle activation rate in each individual may varies the results as well. Hence, future studies are suggested to investigate the muscle activation rate of the individuals in order to rule out the possible confounding factors.

Correlation between SEBT composite score and anthropometric data

From our findings, we concluded that the SEBT composite score has a medium, negative relationship with the weight of the participants, with the value r=-0.433, p<0.05 which is statistically significant. This means the participants with lighter weight will have a better SEBT performance. Meanwhile, it has strong, negative correlation between SEBT composite score with height and limb length, with r=-0.537; p<0.05, and r=-0.628, p<0.05 respectively using Pearson correlation test. An interesting finding in this research is that when looking into aspect of BMI, the results shows there is insignificant weak negative correlation with the SEBT composite score.

In the previous study, the reach distance has been found to be decreased when there is increased in the body mass of the participants (Waddington, Warren, & Diep, 2015). In the study, all the participants performed SEBT with and without the empathy suit and the reach distances were standardized by the limb length of the participants. The results showed that as the body mass of participants increased, a significant decreased in reach distance was found in seven out of eight reach distance. Meanwhile, out of all directions in SEBT, anterior direction was the most affected direction.

Another study on investigating the balance and postural skills in normal-weight and overweight in pre-pubertal boy was done and the results showed the population in overweight category were having lower ability on both static and dynamic balance and postural skills (Deforche et al., 2009). The method used to measure the static and dynamic balance of the participants was a pressure plate which can measures and analyses the vertical component of the center of foot pressure. Even though different method is used to assess the dynamic balance, however both studies showed the consistent results which is the significant correlation between weight and dynamic balance. However, due to the measurement taken was only the weight, the body composition such as body fat percentage is unknown in this study, hence we can only conclude that the body weight and dynamic balance are correlated in a opposite direction, instead of the causality of the result. The possible assumption for this negative correlation between body weight and SEBT may due to the percentage of body fat mass. Also, lower limb muscle strength may not be sufficient enough to support the heavy body while doing the SEBT.

When looking into the correlation of height and SEBT composite score, the results showed there is strong, negative correlation between the height and SEBT composite score, which means the taller participants had significantly lower SEBT composite score. Besides, our findings revealed that there is a strong negative correlation between SEBT score and limb length of the participants ($r=-0.628$, $p<0.05$). However, (P. a Gribble & Hertel, 2012) reported the positive relation between height and limb length to the reach distance in SEBT.

A more recent study was done as well to investigate the correlations between several anthropometric measurements with static and dynamic balance in female college students with sedentary lifestyle (MOEIN & MOVASEGHI, 2016). The results showed a weak, negative correlation between dynamic balance and lower limb length as well as BMI. However, in our study, there is insignificant correlation found between the SEBT composite scores and BMI. The contradiction of the relationship in these studies may due to the results of the possible confounding factors such as body fat percentage, muscle mass, muscle activation rate, vision, and proprioception has not taken into account in this study, which leads to different outcome of the study.

Correlation of peak power and anthropometric characteristic

In our findings, there is significant strong and positive correlation between peak power and weight ($r=0.815$, $p<0.05$) as well as with BMI ($r=0.576$, $p<0.05$) using Spearman correlation test. In a meanwhile, finding revealed that there is also statistically significant strong positive correlation of peak power with height ($r=0.743$, $p<0.05$). From the statistical analysis, it gives us an inference that the higher peak power has a positive relationship in population with larger body weight and height. Also, higher peak power is correlates with participants with higher BMI.

In the year 2012, there was a study done on correlation between BMI and muscle power output in soccer players by (Nikolaidis, 2012). The results showed there was an inverse correlation of BMI and mean power, which is contradictory to our findings. The possible explanation for this contradictory finding is that BMI measurement is not a specific parameter to measure the body composition such as fat mass and also fat-free mass. According to that, there was a study done by (A & A, 2013) who found out that the percentage of body fat is significant negative correlates with leg power. In addition, (Markovic & Jaric, 2007) also suggested that body mass is independent to the muscle power.

However, in our study, the body composition of the participants is unknown, hence it is hardly can get a significant comparison with other studies who compare the body composition and muscle power. Also, the methodology used in the study to measure the muscle power is variant with our study, which might alter the results. Besides, the nature of sports in the study may also lead to a different effect to the outcome.

CONCLUSION

In general, there is an association between dynamic balance and lower limb explosive power among recreational badminton players with chronic ankle instability. Besides, there is an association between dynamic balance with weight, height, limb length, and frequency of playing badminton per week. Also, there is an association between lower limb explosive power with weight, height, BMI, limb length, frequency of badminton per week, and frequency of giving way in the past 6 months.

In a nutshell, the findings revealed small-sized correlation between dynamic balance and lower limb explosive power among recreational badminton players with chronic ankle instability. Hence, we suggested that the dynamic balance and lower limb explosive power shall be trained complementarily.

Conflict of interest

Authors have declared that there is no conflict of interest.

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