RELATIONSHIP OF HAMSTRING MUSCLE FLEXIBILITY TO LEG MUSCLE STRENGTH IN WUSHU ATHLETES

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Abstract. Wushu is now a sport that is gaining interest among various groups, from children to adults. The most common injury in wushu athletes is hamstring muscle injury which accounts for 12%. Hamstring muscle injuries in wushu athletes can occur due to overstretching of the hamstring muscles leading to the sudden and explosive movements and finally a decrease in leg muscle strength. Maintaining hamstring muscle flexibility and leg muscle strength in wushu athletes is essential as both impact on the optimal ability when competing. This cross-sectional research aimed to find out whether there was a relationship between hamstring flexibility and leg muscle strength in wushu athletes. The instruments used to measure hamstring flexibility were the V Sit and Reach Test and while the Leg Dynamometer was used to measure leg muscle strength. Participants of this study were 43 wushu athletes at the Ghenta Dewata Bali Wushu Gym recruited by purposive sampling. This study found a relationship between hamstring muscle flexibility and leg muscle strength (p<0.001). The Pearson correlation result shows a positive and unidirectional value (r = 0.844). Thus, it can be interpreted that an increase in hamstring flexibility results in an increase in leg muscle strength.

Keywords: exercise, wushu, sport, flexibility hamstring, strength muscle, lower leg

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INTRODUCTION

Nowadays the development of sports is rapidly increased. This condition can be seen from the increasing number of people doing sports activities, both old, young and children (Latifa and Niswah, 2017). One form of sport that is often made to improve efforts by competing is achievement sports. Sports achievements, according to Law Number 11/2022 concerning the National Sports System (Government of Indonesia, 2022), are sports that foster and develop sportsmen in a planned, tiered, and sustainable manner through competitions to achieve achievements at the regional, national, and international levels in order to improve the dignity and dignity of the nation with the support of sports science and technology.

As an athlete, injury is something that athletes, including wushu athletes, fear. When an injury occurs, it will affect the athlete's performance and achievement. Injuries that occur also cause problems in body conditions such as decreased hamstring flexibility and decreased muscle strength of wushu athletes.

One sport that continues to grow today is wushu. Wushu has been included in one of the leading sports in the National Sports Grand Design (NSGD) and has been determined by the government through Presidential Regulation Number 86/2021 concerning National Sports Grand Design (NSGD) (Government of Indonesia, 2021). The determination of wushu as a leading sport is due to studies conducted by academics, experts and sports practitioners by looking at the development of Indonesian wushu achievements from 2010 to 2021 (Ministry of Youth and Sports, 2022). In 1992, wushu was established for the first time in Indonesia and has been running from time to time. Now the development of wushu has arrived in Bali and continues to experience the development and increase

in the number of wushu athletes and students (Ambara, 2017). There are 688 athletes and wushu students in Bali and this number is growing. Along with the increase in the number of wushu athletes, various types of wushu competitions are carried out to get the students who would be able to take part in national and international championships. Some competition activities that have been held in the province of Bali such as the Provincial Sports Week, Regional Championships, Provincial Championships and others (Yusuf *et al*, 2021).

Wushu is a sport that requires physical components such as muscle strength, joint stabilization, balance and good muscle explosiveness. If these physical components are not maintained or cared for, it can increase the risk of injury. One of the injuries often experienced by wushu athletes is injuries to the lower extremities, both acute injuries and due to overuse (Vitale *et al*, 2018). Many young wushu athletes experience complaints of injuries to musculoskeletal limbs, especially in the lower extremities such as knees, ankles and others.

Based on research conducted by Pramono (2022), 68.75% of wushu athletes have a risk of injury to the lower extremities and 31.25% have a risk of injury to the lower extremities of the low category in the CSWI Surabaya Wushu community in adolescence. Most athletes are at risk of injury to the lower extremities, with over 50% of athletes getting a single leg balance test result of <30 seconds (Pramono, 2022).

Based on research conducted by Yiemsiri and Wanawan (2014), injuries are not only obtained during training but the incidence of injuries occurs during official matches or championships with a prevalence of 75% of injury incidents. Injury is a disorder that occurs in the body that results in pain, heat, redness, swelling, and cannot function well in muscles, tendons, ligaments, joints, and bones due to excessive movement activities or accidents. Injuries can occur in the training process during

the preparation period before the competition and in the competition process. Various factors can cause injury such as training method errors, musculoskeletal structural abnormalities and physiological weaknesses in the function of supporting tissues and muscles. In addition to injury, shortening of the hamstring muscles can also cause a decrease in hamstring flexibility. This condition can occur due to lack of exercise that focuses on the hamstring muscles or lack of stretching for the hamstring muscles so that it can limit movement of the lower legs. In particular, the physical component that must be considered for wushu is the lower extremities which, in this section, is an important part that must be maintained and cared for by adolescent wushu athletes. If there is a sports injury, the ability to move and physical function decreases. Based on Wiguna *et al* (2016), it was recorded that on average every season an athlete experienced two injuries and the most cases were hamstring injuries 12%, followed by meniscus cruciate ligament (MCL) injuries of 9% and quadriceps as much as 7%. Some of the main components needed in wushu are lower leg muscle flexibility, leg muscle strength and body balance (Rovendra, 2021). The increase in flexibility of the lower leg muscles, especially the hamstring, which is a large muscle group, can increase the ability of the lower leg muscles, thereby reducing the incidence of injury.

Flexibility is the ability of tendons and muscles to shorten and lengthen without limited joint motion. Flexibility itself can be defined as the effectiveness of individuals in adjusting to various activities with the stretching of the body on a wide joint plane. When hamstring muscle flexibility is good, it will increase agility, lower the risk of falls, increase physical activity. When there is an injury to the hamstring can be caused by the flexibility of the hamstring muscles that decrease and cause the hamstring muscles to shorten so that the ability of muscle contractility

decreases (Rovendra, 2021). Poor hamstring flexibility can affect leg muscle strength ability.

Muscle strength is an important component of physical fitness, because the degree of ability adjustment occurs according to the proportion of the quality and number of muscle fibers (Manullang *et al*, 2022). Muscle strength can be interpreted as the quality of muscle power or a group of muscles in building maximum contractions to cope with loads that come both from within and from outside. So, the movements made by the leg muscles will produce activity movements such as kicking, walking, jumping and so on (Hartanto *et al*, 2021). Where the movement is needed in carrying out sports movements, especially sports that predominantly use the legs such as wushu. Muscle strength plays an important role in protecting athletes from injury and helping to stabilize joints (Manullang *et al*, 2022). Leg muscle strength is an important component of physical freshness, because good leg muscle strength is seen from the degree of adjustment of muscle ability and occurs according to the proportion of the quality and number of muscle fibers (Julianto, 2019). Muscle strength can be defined as the quality of muscle power or a group of muscles in building maximum contractions to cope with loads that come both from within and from outside.

Good hamstring flexibility can result in maximum kicks. In performing optimal kicks, it is necessary to pay special attention to physical condition which is the main supporting factor which involves flexibility and leg muscle strength and has a major influence on producing quality and optimal kicks, especially in wushu matches.

From these problems, researchers were interested in knowing whether there was a relationship between hamstring flexibility and leg muscle strength in wushu athletes.

MATERIALS AND METHODS

This study aimed to determine the relationship of hamstring flexibility to leg muscle strength in wushu athletes. The scientific scope in this study is physical fitness especially hamstring flexibility and leg muscle strength in wushu athletes. The research was carried out from June - July 2023 at Sasana Wushu Ghenta Dewata Tabanan in Bali, Indonesia. This study used quantitative methods with analytical observational research and a cross-sectional design.

The population of this study was all the wushu athletes at Ghenta Dewata Bali Wushu Gym, comprising 84 wushu athletes. The inclusion criteria in this study were wushu athletes aged 6-12 years, both boys and girls, and parents of respondents approved their children to participate in this study by signing the assent form. The exclusion criteria in this study were wushu athletes who suffered upper and lower extremity fractures, experiencing acute inflammation of the neck, lower back, ankle, low back pain and having a herniated nucleus pulposus and undergoing physiotherapy treatment or were in another research program.

To calculate the sample size in this study using Fisher's formula, as follows:

$$n = \frac{Z_{\alpha}^{2} P(1\text{-}P)}{d^{2}}$$

Where n = required minimum number of samples

Z_{α} = value of the standard normal distribution reflecting the confidence level that will be used (Z value for α of 0.05 is 1.96)

P = prevalence of hamstring injury which is 0.12 according to Wiguna *et al*, (2016)

d = deviation to the desired population (which was 10%)

Based on the formula above, the minimum number of samples in this study was 40.5 individuals. In anticipation of the sample dropping out, 5% was added so that it became 43 wushu athletes.

In this study, a V Sit and Reach Test (Pérez-Vigo *et al*, 2022) was used to measure flexibility in the hamstring muscles and the results of measurement come out as less, normal, good and very good flexibilities. Leg Dynamometer (Takei TKK-5002 Back Leg Chest Strength Dynamometer Tester; Takei Scientific Instruments Co Ltd, Niigata, Japan) was used to measure leg muscle strength with good, moderate and less strengths were reported.

Statistical analyses used in quantitative approaches were descriptive and chi-square tests. Descriptive analysis was utilized in reporting the percentage and frequency of age, sex, age, hamstring flexibility and leg muscle strength data. Chi-square test was used to analyze the relationship of hamstring flexibility to leg muscle strength in wushu athletes.

This research has received ethical clearance approval with No. 01.042/UNBI/EC/V/2023. Respondents and parents of respondents who participated in the study were voluntary and there was no pressure or coercion from any party. Respondents are guaranteed confidentiality from identity by not including names but using respondent numbers set by researchers.

Table 1

Characteristics of respondents (N = 43)

Characteristic	Frequency *n* (%)
Age (years)	
6	2 (4.6)
7	11 (25.5)
8	5 (11.6)
9	6 (14.0)
10	6 (14.0)
11	7 (16.3)
12	6 (14.0)
Gender	
Male	26 (60.5)
Female	17 (39.5)

RESULTS

Characteristics of respondents

Based on Table 1, it shows that the age of respondents who participated in wushu was dominated by 7 years (*n*=11, 25.6%). The least age to participate in wushu was 6 years (*n*=2, (4.7%). Most participants were male (*n*=26, 60.5%).

In Table 2, it shows that majority of respondents with normal hamstring flexibility had moderate leg muscle strength scores (*n* = 15, 34.9%). Furthermore, respondents with good hamstring flexibility had moderate leg muscle strength (*n*=9, 20.9%). Subsequently, it shows that

Table 2

Cross table of hamstring flexibility and leg muscle strength (N = 43)

Measurement	Leg muscle strength, *n* (%)				*p*-value	r
	Good	Moderate	Less	Total		
Hamstring flexibility					0.001	0.844
Very good	3 (7.0)	0 (0.0)	0 (0.0)	3 (7.0)		
Good	5 (11.6)	9 (20.9)	0 (0.0)	14 (32.6)		
Normal	0 (0.0)	15 (34.9)	2 (4.7)	17 (39.5)		
Less	0 (0.0)	0 (0.0)	9 (20.9)	9 (20.9)		
Total	8 (18.6)	24 (55.8)	11 (25.6)	43 (100.0)		

r: correlation coefficient

respondents with good hamstring flexibility had good leg muscle strength (n = 5, 11.6%).

The results of this study showed that there was a significant relationship between hamstring flexibility and leg muscle strength with a p-value of <0.001.

The Pearson correlation result shows a positive and unidirectional value (r = 0.844).

DISCUSSION

Based on Table 1, it can be seen that male gender respondents are more dominant; this is related to the nature of this sport which has physical contact and requires great energy. Wushu is a sport that is synonymous with punches, kicks, deflections, slams, agility, with energy and either in Kata (moves) or Kumite (fight). Sports that are characterized by violence, strength, speed, courage, and leadership, are traits identified with men. To be seen manlier, men choose sports that are martial arts, such as wushu (Amani and Priambodo, 2019).

It is possible that women also have an interest in wushu sports. Based on Table 1, it can be seen that there are 17 female respondents (39.5%). This proves that there are several intrinsic and extrinsic factors that attract martial arts for women. Based on Amani and Priambodo (2019), there are several intrinsic factors that attract woman to join martial arts such as parental support, friends, rewards, and community (Amani and Priambodo, 2019)

Based on Table 2, 39.5% of wushu athlete has normal hamstring flexibility while by 32.6% has good hamstring flexibility and 7% has

very good hamstring flexibility. Where in wushu practice, there is flexibility training which is one type of exercise that is important because wushu techniques involve fast movements and stretching techniques. Inadequate flexibility or decreased flexibility ability in wushu athletes can pose a risk of injury (Huang *et al*, 2018). So, to be able to prevent injury, basic motion training in wushu includes flexibility training so as to allow athletes in this study to achieve the V Sit and Reach Test with a higher value. Based on research conducted by Pangemanan *et al* (2012) , students who are trained in sports will have much better ability or muscle strength than students who rarely do sports activities. Through regular, programmed, and well-planned exercises, students will be able to maintain good physical condition, fitness, physical and mental health, and build their muscles. Doing exercise means investing in the body, a longer life, better health, a more passionate life, and sustainable happiness. Wushu sports, when routinely carried out, affect the strength and muscle mass, as well as joint flexibility (Pangemanan *et al*, 2012).

In this study, 9 respondents (20.9%) had less hamstring flexibility. The flexibility of a joint can be influenced by internal factors, including the type of joint, bone structure that causes limitation of movement, and the elasticity of muscle tissue, tendons, ligaments, and skin. The ability to contract and relax muscles, and the temperature of the joints and surrounding tissues can also affect flexibility. There are external factors that are no less important influence on flexibility; among others are the temperature of the training ground, the specific time of day, the level in the healing process of the joint after injury, age, gender, exercise, and limitations due to clothing or the use of other equipment on the joint (Behnke and Plant, 2021). According to Spinoso *et al* (2022), decreased flexibility can contribute to postural changes, the deficit in the ability to produce strength, and predispose to injuries. The reduction in flexibility

is due to the adaptive shortening of the musculature, tendons, and other soft tissues, such as fascia, which are maintained for a long time at some angle of contraction, so in a sitting position, the hamstrings tendons are loose and shorten to increase the tension in the muscle, decreasing the range of joint movement of the joints involved (Spinoso *et al*, 2022).

Muscle strength is greatly influenced by the size of the muscle (Setiawan and Setiowati, 2014). The results of this present study, a total of 74.4% of the respondents with moderate to good muscle strength, are in line with Pangemanan *et al* (2012) who reported the stronger the muscle, the better the strength of the leg muscle and that the muscle size and length were affected by bearing and heredity.

Based on the results of this study, it was found that most wushu athletes had moderate and normal leg muscle strength which can be the result of routine training carried out by wushu athletes. Although there is evidence that muscle strength training can increase the number of myofibrillar cross sectional area type I/II fibers and increase muscle mass, physiologists tend to think that muscle enlargement is the result of muscle fiber expansion following the exercises (Maestroni *et al*, 2020).

Wushu athletes in this study do exercises regularly and wushu movements that involve a lot of lower limbs can affect muscle strength in wushu athletes. In line with Huang *et al* (2018) who mentioned that when wushu was regularly performed, athletes were engaged in strength training for the lower limbs thus leading to a greater muscle strength and better performance in dynamic balance tests.

In this study, 11 respondents (25.6%) had less leg muscle strength which could due to biomechanical factors, age, physical fitness, gender, psychological factors, genetic factors, maturity, body size, physical activity and motor abilities. This is in line with Boujdi *et al* (2023) who

mentioned that physical activity can make impacted and good lifelong habits regarding physical activity were established, benefiting from the muscle strength improvement with age. This proves that leg muscle strength in children will increase with age and increased physical activity such as regular exercise will increase muscle strength.

Leg muscle power is the tension exerted by the leg muscles against the tension or load with maximum effort to move the muscles. Every athlete in any sport is required to have good physical condition to support the desired achievement. The physical condition can be improved by practicing. One of the factors that plays a role in the achievement is the physical condition, including the power of the leg muscles. When wushu athletes have a history of injury, they experience less leg muscle strength. Such injuries can cause a decrease in muscle strength due to the inability of the muscles to withstand the weight received. Hamstring muscle injury will shorten the muscle leading to a decrease in muscle elasticity and flexibility. When the muscle get injured, its response is shorten and tighten making it works harder than usual (Huygaerts *et al*, 2020).

Generally, people would have had moderate leg muscle strength; as seen in this study, 15 out of 43 respondents (34.9%) did have moderate leg strength when they also had normal hamstring muscle flexibility. Good hamstring flexibility and leg muscle strength will result in good kick movement.

In this study, it was seen that wushu athletes were spread in the normal, good and very good categories on hamstring flexibility and on muscle strength wushu athletes tended to be moderate and good. Having normal, good and very good hamstring flexibility can be the results of a warm up session required before training. In warm-up session, there

is stretching for hamstring muscles which can affect flexibility of the muscle (Chang *et al*, 2020). More frequent exercises can increase the ability of hamstring muscle flexibility and leg muscle strength while doing kick performance (Pramono, 2022). Wushu sports display various attack skills and perform extreme movements that require maximum hamstring flexibility and leg muscle strength. Good hamstring flexibility can prevent wushu athletes from the risk of injury. When there is an injury to the hamstring muscles, the strength of the lower leg muscles is decreased (Huygaerts *et al*, 2020). Flexibility is the ability of joints to perform movements in joint space optimally (Widiastuti, 2015). Therefore, wushu athletes who want to perform optimal movements need a proper warm-up in accordance with the dominant movements in wushu. Movement in wushu requires leg muscle strength to be able to produce optimal kicks. A study conducted by Ambara (2017) found that the hamstring muscle flexibility of male Wushu Sanda athletes at Sasana Kim Tiauw Surabaya was in the very good category. Research conducted by Hardyanti and Siantoro (2022) found the average abdominal muscle strength, hand muscle strength and endurance in wushu athlete boys Wanoro Seto Academy Surabaya in the good category.

There were 9 respondents (20.9%) with less hamstring flexibility and less leg muscle strength. This is in line with Cha *et al* (2021), who reported that the majority of athletes with wushu have less hamstring flexibility or lack of flexibility in hamstrings, which can be caused by not being routinely trained or experiencing injuries of the lower leg area.

Wushu is included in the category of body contact sports so the risk of possible injury is very large. An athlete who has good flexibility can avoid the possibility of physical injury allowing them to perform movements with wide joint space (Kurniawan, 2018).

In addition, the value of correlation coefficient (r) of 0.844 shows that there is a strong positive relationship in hamstring flexibility with muscle strength, ie a decrease in flexibility can decrease in muscle strength, and vice versa.

In summary, Wushu athletes at Ghenta Sasana Dewata Bali Gym aged 6-12 years have, on average, normal to excellent hamstring flexibility and moderate to good leg muscle strength. This study shows that there is a positive relationship between hamstring flexibility and leg muscle strength. The results of this research can be used as a basis for wushu coaches and wushu athletes to carry out more complex warm-up exercises in the lower leg area, especially in large muscles such as the hamstrings, biceps femoris, and anterior tibia, to increase flexibility, muscle strength, and muscle endurance to avoid injury to athletes and maximize athlete abilities. Wushu coaches and athletes should be able to maintain the flexibility of the hamstring muscles and the strength of the leg muscles to avoid injury, so that it will produce good-quality match results.

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CONFLICT OF INTEREST DISCLOSURE

The authors declare that there is no conflict of interest regarding the publication of this paper. The authors declare that they have no known

competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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