ปัจจัยทางกายวิภาคศาสตร์และชีวกลศาสตร์ที่มีความสัมพันธ์กับภาวะเอ็นรองฝ่าเท้าอักเสบในกลุ่มทหารเกณฑ์เพศชายชาวไทย

นางสาวภาวิณี หฤทัยชื่น

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรดุษฎีบัณฑิต
สาขาวิชากายภาพบำบัด ภาควิชากายภาพบำบัด
คณะสหเวชศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2560

ANATOMICAL AND BIOMECHANICAL FACTORS ASSOCIATED WITH PLANTAR FASCIITIS IN THAI MALE CONSCRIPTS

Miss Pavinee Harutaichun

A Dissertation Submitted in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy Program in Physical Therapy
Department of Physical Therapy
Faculty of Allied Health Sciences
Chulalongkorn University
Academic Year 2017

Thesis Title	ANATOMICAL AND BIOMECHANICAL FACTORS ASSOCIATED WITH PLANTAR FASCIITIS IN THAI MALE CONSCRIPTS
By	Miss Pavinee Harutaichun
Field of Study	Physical Therapy
Thesis Advisor	Assistant Professor Praneet Pensri, Ph.D.
Thesis Co-Advisor	Assistant Professor Sujitra Boonyong, Ph.D.

Accepted by the Faculty of Allied Health Sciences, Chulalongkorn University in Partial Fulfillment of the Requirements for the Doctoral Degree

....Dean of the Faculty of Allied Health Sciences
(Assistant Professor Palanee Ammaranond, Ph.D.)

THESIS COMMITTEE

....Chairman
(Assistant Professor Keerin Mekhora, Ph.D.)

....Thesis Advisor
(Assistant Professor Praneet Pensri, Ph.D.)

....Thesis Co-Advisor
(Assistant Professor Sujitra Boonyong, Ph.D.)

....Examiner
(Assistant Professor Rotsalai Kanlayanaphotporn, Ph.D.)

....Examiner
(Sukanya Eksakulkla, Ph.D.)

....Examiner
(Montakarn Chaikumarn, Ph.D.)

ภาวิณี หฤทัยชื่น : ปัจจัยทางกายวิภาคศาสตร์และชีวกลศาสตร์ที่มีความสัมพันธ์กับภาวะเอ็นรองฝ่าเท้าอักเสบในกลุ่มทหารเกณฑ์เพศชายชาวไทย (ANATOMICAL AND BIOMECHANICAL FACTORS ASSOCIATED WITH PLANTAR FASCIITIS IN THAI MALE CONSCRIPTS) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: ผศ. ดร. ปราณีต เพ็ญศรี, อ.ที่ปรึกษาวิทยานิพนธ์ร่วม: ผศ. ดร. สุจิตรา บุญหยง, 186 หน้า.

สาเหตุของการเกิดภาวะเอ็นรองฝ่าเท้าอักเสบนั้นพบได้จากหลายปัจจัย ดังนั้นการศึกษาปัจจัยที่เกี่ยวข้องกับการเกิดภาวะดังกล่าวจึงควรใช้สถิติสำหรับการวิเคราะห์หลายตัวแปร การวิจัยครั้งนี้จึงมีวัตถุประสงค์หลักเพื่อศึกษาปัจจัยส่วนบุคคลที่เกี่ยวข้องกับการเกิดภาวะเอ็นรองฝ่าเท้าอักเสบในกลุ่มทหารเกณฑ์เพศชายชาวไทย ทหารเกณฑ์ทั้งหมด 270 คนที่ไม่มีประวัติอาการบาดเจ็บทางระบบกระดูกและกล้ามเนื้อของหลังส่วนบั้นเอวและรยางค์ขาในช่วง 3 เดือนที่ผ่านมา จะได้รับเชิญให้เข้าร่วมงานวิจัยในช่วงก่อนเข้ารับการฝึกทางทหาร และได้รับการประเมินปัจจัยที่เกี่ยวข้องข้างต้น หลังจากเสร็จสิ้นการฝึกทางทหารเป็นระยะเวลา 10 สัปดาห์นั้น พบว่า มีทหารเกณฑ์จำนวน 71 คนที่มีภาวะเอ็นรองฝ่าเท้าอักเสบ และอีกจำนวน 42 คนที่ไม่มีอาการบาดเจ็บทางระบบกระดูกและกล้ามเนื้อตลอดช่วงการฝึกทางทหาร ดังนั้นข้อมูลเกี่ยวกับปัจจัยส่วนบุคคล ซึ่งรวมไปถึงผลการตรวจประเมินทางกายภาพบำบัดของทั้งรยางค์ขาที่ได้จากทหารเกณฑ์จำนวนทั้งหมดดังกล่าวตั้งแต่ก่อนเริ่มต้นการฝึก จะถูกนำมาวิเคราะห์การถดถอยโลจิสติกเชิงพหุแบบขั้นบันได (stepwise method) เพื่อหาปัจจัยทำนายที่ระดับนัยสำคัญทางสถิติ 0.05 ผลจากการศึกษาพบว่า ทหารเกณฑ์ที่มีคุณภาพการเคลื่อนไหวของรยางค์ขาในระดับต่ำจะมีความเสี่ยงต่อการเกิดภาวะเอ็นรองฝ่าเท้าอักเสบ (OR = 1.996) ในขณะที่ทหารเกณฑ์ที่มีมุม Femoral anteversion เพิ่มขึ้นจะมีความเสี่ยงต่อการเกิดภาวะเอ็นรองฝ่าเท้าอักเสบลดลง (OR = 0.720) นอกจากนี้ทหารเกณฑ์ที่มีค่าดัชนีมวลกายและระดับความเครียดที่มาก จะเพิ่มปัจจัยเสี่ยงต่อการเกิดภาวะเอ็นรองฝ่าเท้าอักเสบ (OR = 1.238 และ 1.110 ตามลำดับ) ในขณะที่ทหารเกณฑ์ที่มีระดับกิจกรรมทางกายสูงตั้งแต่ก่อนเข้ารับการฝึกทางทหารจะมีความเสี่ยงต่อการเกิดภาวะเอ็นรองฝ่าเท้าอักเสบลดลง (OR = 0.242) กล่าวโดยสรุปจากผลการศึกษานี้คือ มีหลายปัจจัยส่วนบุคคลที่มีความสัมพันธ์ต่อการเกิดภาวะเอ็นรองฝ่าเท้าอักเสบในกลุ่มทหารเกณฑ์เพศชายชาวไทย ซึ่งรวมถึงปัจจัยทางด้านกายวิภาคศาสตร์และชีวกลศาสตร์ของรยางค์ขาส่วนต้นนอกเหนือไปจากส่วนของเท้าและข้อเท้า

ภาควิชา กายภาพบำบัด	ลายมือชื่อนิสิต ....
สาขาวิชา กายภาพบำบัด	ลายมือชื่อ อ.ที่ปรึกษาหลัก ....
ปีการศึกษา 2560	ลายมือชื่อ อ.ที่ปรึกษาร่วม ....

5676958837 : MAJOR PHYSICAL THERAPY

KEYWORDS: PLANTAR FASCIITIS / MILLTARY TRAINNING / ANATOMICAL / BIOMECHANICAL / PSYCHOLOGICAL / LOWER EXTREMITY

PAVINEE HARUTAICHUN: ANATOMICAL AND BIOMECHANICAL FACTORS ASSOCIATED WITH PLANTAR FASCIITIS IN THAI MALE CONSCRIPTS. ADVISOR: ASST. PROF. PRANEET PENSRI, Ph.D., CO-ADVISOR: ASST. PROF. SUJITRA BOONYONG, Ph.D., 186 pp.

Etiology of plantar fasciitis among novice conscripts is multifactorial. The combination of all potential factors should be included for multivariate analysis to determine the significant predictors. The present study aimed to identify the intrinsic predictors of plantar fasciitis among novice conscripts. Two hundred and seventy healthy male conscripts who were without lower back or lower extremity pain prior to the commencement of military training were participated in this study. Intrinsic predictors which included individual, anatomical, and biomechanical variables were assessed at baseline. After 10 weeks of training, 113 participants were assessed again and classified as having (n = 71) or not having (n = 42) plantar fasciitis. Multiple logistic regression was used to identify significant predictors. The primary criterion variable was the presence or absence of plantar fasciitis. Current results indicated that the conscripts with poorer quality of movement were two times more likely to exhibit plantar fasciitis (OR = 1.996). The conscripts with more femoral anteversion angle decreased the risk of presenting with plantar fasciitis (OR = 0.720). Regarding individual component, the conscripts with higher body mass index and more stress level increased more risk of plantar fasciitis (OR = 1.238 and 1.110, respectively). In addition, the conscripts with higher physical exercises level before military program reduced the risk of presenting with plantar fasciitis (OR = 0.242). In conclusion, multiple factors – especially individual characteristics and the abnormalities from proximal region (other than foot and ankle) – contributed to the prediction of the development of plantar fasciitis among Thai conscripts.

Department:	Physical Therapy	Student's Signature	....
Field of Study:	Physical Therapy	Advisor's Signature	....
Academic Year:	2017	Co-Advisor's Signature	....

ACKNOWLEDGEMENTS

Sincerely thanks are due to all people who have directly or indirectly influenced and contributed to my research. I am especially indebted to Assistant Professor Dr. Praneet Pensri and Assistant Professor Dr. Sujitra Boonyong who support me throughout my thesis. Without their valuable suggestion, inspiration and motivation, this thesis would not have been completed. My deepest gratitude is also extended to Professor Dr. Prawit Janwantanakul and Professor Dr. Mark P. Jensen for their recommendation on the manuscript production.

I wish to thank Assistant Professor Dr. Keerin Mekhora, Assistance Professor Dr. Rotsalai Kanlayanaphotporn, Dr. Montakarn Chaikumarn and Dr. Sukanya Eksakulkla for their kindness, guidance and valuable suggestions. In addition, I wish to thank Mr. Vasapol Teravanapanth for Mathlab analysis.

I am particular indebted to the scholarship from “The 100th Anniversary Chulalongkorn University Fund for Doctoral Scholarship” and "Faculty of Allied Health Sciences, Chulalongkron University". The authors would like to thank the Thai male conscripts from the Infantry Battalion of 11th Military Circle, the center camp of military training in Bangkok for their participation in this research. I also would like to extend my gratitude to Ethical Committee of Chulalongkorn University, for providing an ethical approval.

I am also greatful towards my teachers at the Faculty of Allied Health Sciences, Chulalongkorn University for their kind advice and moral support. I would also extend my special thanks to all supporting staff who contributed to my study. My thankfulness is also extended to Ms. Rattanaporn Sonpeayung, Ms. Narintip Roongbenjawan, Ms. Chathipat Kruapanich, Ms. Duangporn Suriyaamarit, Mr. Pawan Chaiparinya and all of my classmates for their suggestion and kind support.

This thesis is dedicated with deepest love to my parents. Their love, encouragement and understanding have inspired me to be the best that I can be. And I hope this thesis is the best thing that represents my thankfulness to them.

CONTENTS

Page

Page

Page

Page

LIST OF TABLE

Page

LIST OF FIGURE

Page

CHAPTER 1

INTRODUCTION

1.1 Background and Rationale

Plantar fasciitis is an overuse syndrome that affects up to 15% of all adult foot complaints and 10% of the population over the course of a lifetime. It accounts for 8-10% of running or training related injury and 80% of heel pain (1, 2). Plantar fasciitis is the most common foot condition diagnosed by health care provider. It has been estimated that more than 1 million patients with plantar fasciitis seeking for professional care in each year (2, 3). Diagnosis of plantar fasciitis is based on physical examination and patient history(4). Most patients have medial heel pain at the origin of plantar fascia which is due to repetitive force in weight-bearing position. They typically complain their first-step pain in the morning or after non weight-bearing position for prolonged time; however, the symptom will decrease gradually after walking for a few steps. Moreover, heel pain is aggravated after prolonged standing, prolonged walking, barefoot walking, tip-toe walking, and stair climbing (2, 3). On physical examination tests, the findings generally reveal that patients' sensations are intact. Patients with moderate-to-severe heel pain may avoid shifting weight on the painful foot or walk with antalgic gait. Palpation on medial side of the calcaneus will elicit stabbing or sharp pain, radiating into the arch of the foot (4). The nature of pain from plantar fasciitis is not usually disabling; however, it has impacts on the restriction of the ability to perform weight-bearing activities in daily life, work, social and family functions (5).

The etiology of plantar fasciitis is probably multifactorial. The condition is likely to occur in obese persons, working adults with sedentary life and young adults with intense physical activity (3, 6). Regarding to the running or training related with an overuse injury from plantar fasciitis, previous studies reported a number of risk factors which included greater training frequency, training duration, training on hard surface, inappropriate footwear, as well as sudden changes in running variables such as distance, frequency, speed, and surface (6, 7). Anyways, the inverse association was found between the previous physical activity level and subsequent injury among military recruits during their training. Individuals with higher level of physical activity had a trend to decrease the risk of overuse injury (8).

Plantar fasciitis is an overuse injury that commonly related with prolonged weight-bearing activities (9). Considering the training-related with injury, the military program consists of high-load weight bearing exercises; thus, this occupation may have higher risk to increase lower-extremity injuries (8, 10). The previous study reported the highest prevalence of overuse injury at lower extremity when compared with spine and upper extremity region among Thai military recruits (11). Basic training program for Thai conscripts included long distance of running for approximately 8 km per day, inverted crawls, hops, high jumps as well as hiking with pack and equipment which might be related with a number of lower-extremity injuries (11). However, the etiology among military trainees is not fully understood. The condition is considered to be multifactorial and numerous risk factors are implicated in its development.

Furthermore, some anatomical and biomechanical factors were reported as the main potential risk factors to develop the condition among the runners and the military trainees (12, 13). The anatomical impairments from the previous findings consisted of limited ankle dorsiflexion, limited 1st metatarsophalangeal joint movement, heel pad thickness, flat arched foot, high arched foot, excessive pronation of the foot, and calcaneal spur (6, 14-16). Repetitive microtrauma at proximal attachment of the plantar fascia may induce the loss of fascia elasticity, resulting in the reduction of medial arch height and excessive pronation movement at midfoot (14, 17, 18). Plantar fasciitis feet are likely to be an excessive kinematic version of normal foot mechanics (18-21). Compared with uninjured feet, plantar fasciitis feet exhibited greater rearfoot motion in frontal plane, forefoot motion in frontal plane, and higher arch flattening during the stance phase of gait cycle (21), of which were consistent with the theoretical causation of plantar fasciitis (17).

Based on the concept of overload condition as seen in Figure 1.1, the change in mechanical properties of the plantar fascia from its tensile overload leads to the gradually anatomical alteration including ankle plantarflexors inflexibility and weakness. This may affect the functional biomechanical deficit which involves the abnormal gait adaptation (17). It has been postulated that there is anatomical connection between Achilles tendon and plantar fascia; thus the tensile stress of plantar fascia may increase the tension in Achilles tendon (22). Both the inflexibility and deficit strength of Gastrosoleus muscles lead to the change of foot kinematics during the stance phase of gait cycle (17). The inflexibility of Gastrosoleus muscles causes an excessive midfoot pronation which is due to a compensatory mechanism from a lack of ankle dorsiflexion movement during the midstance subphase; while the deficit strength of those results in restriction of midfoot supination to provide arch stability during the propulsive subphase (1, 3, 23). Abnormal foot biomechanic such as excessive foot pronation may lead to the functional change of lower-extremity kinetic chain that could provide the path of least resistance to motion and the site of compensation for various proximal structures such as lower extremity muscles, ankle joint, knee joint, and hip joint (24).

In addition, the abnormal control of hip musculature, especially hip abductors can also lead to the mechanic changes in lower parts during walking (25, 26). The hip abductors function to prevent a frontal plane pelvic drop during the stance phase of gait cycle; the impairment may have kinematic consequences of increased femoral adduction and femoral internal rotation, possibly followed by tibial internal rotation which can lead to poor shock absorption and decreased pronation control, resulting in the repetitive injuries of distal part and more tensile stress of the plantar fascia during walking (25, 26). The previous study about hip musculature control in foot and ankle pathology found that women with posterior tibial tendon dysfunction had the lower strength and endurance of ankle plantarflexors, hip external rotators, and hip abductors compared with the control subjects (26). However, there is no similar study among the patients with plantar fasciitis. Furthermore, the studies of kinematic changes in plantar fasciitis are only emphasized on the foot motion using either single-rigid foot model or multi-segment foot model without the consideration of pelvic, hip and, knee kinematics (18, 20, 21, 27). Therefore, further studies are needed to investigate the kinematics difference of the lower extremity between individuals with plantar fasciitis and healthy subjects.

Repetitive microtrauma at proximal attachment of plantar fascia may enhance anatomical alteration of lower extremity including both the inflexibility and deficit strength of Gastrosoleus muscles that lead to the change of foot kinematics during the stance phase of gait cycle (17). The previous study reported an excessive foot kinematics as well as a decreased arch height (21) among individuals with plantar fasciitis. Based on the review of literature, we assume that multiple intrinsic factors including anatomical and biomechanical factors of hip and knee may be also associated with plantar fasciitis, as hypothesized in Figure 1.2. Further studies are needed to compare the change in anatomy and biomechanics of lower extremity between individuals with and without plantar fasciitis. Therefore, the aims of the study are to determine the association between intrinsic factors (individual, anatomical and biomechanical factors) and the presence of plantar fasciitis and to investigate the differences of lower-extremity kinematics between individuals with and without plantar fasciitis in Thai male conscripts.

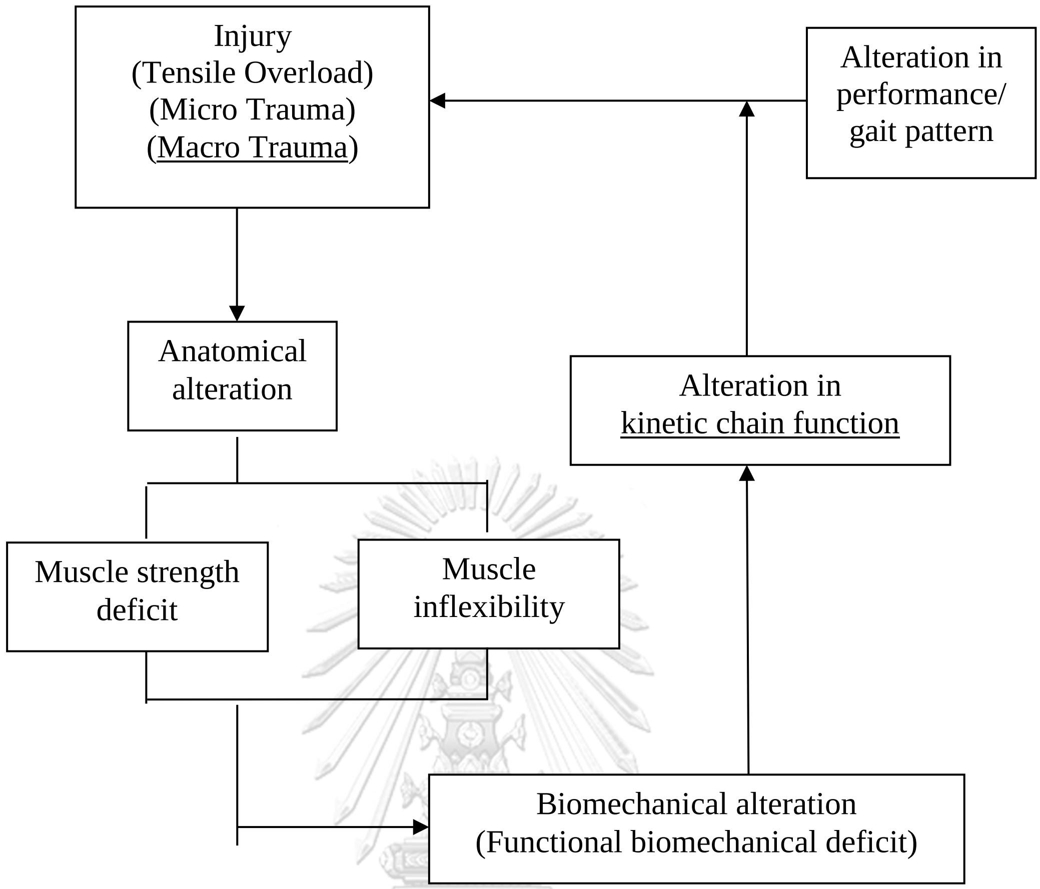


Figure 1.1 Theoretical causation of plantar fasciitis

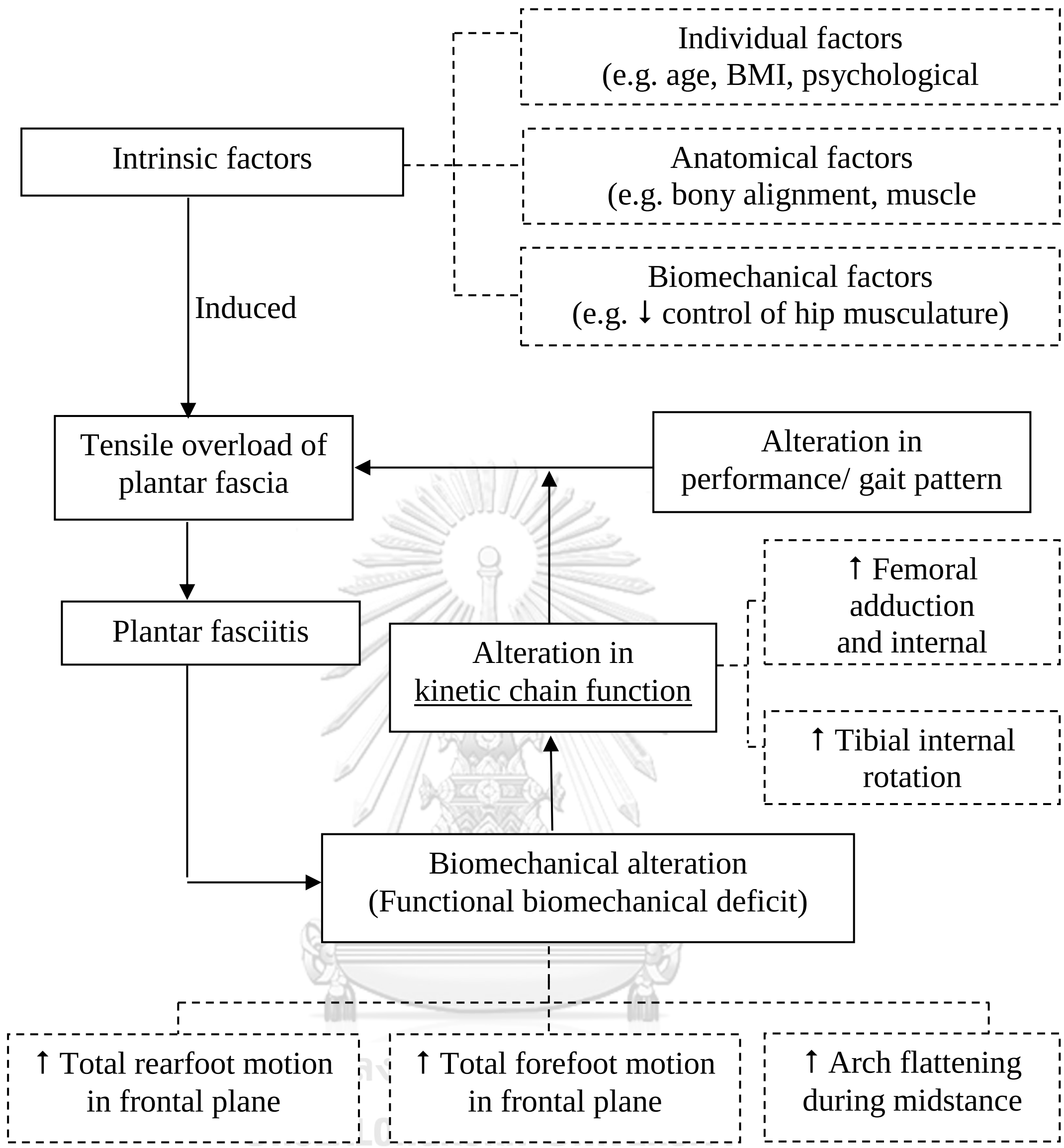


Figure 1.2 Conceptual Framework of the present study

1.2 Research Questions

- Are there any associations between intrinsic factors and the presence of plantar fasciitis in Thai male conscripts?
- Are there any associations between intrinsic factors and the average pain intensity during last week from plantar fasciitis in Thai male conscripts?

- Are there any differences in lower-extremity kinematics between the subjects with and without plantar fasciitis during the stance phase of gait cycle in Thai male conscripts?

1.3 Research Objectives

- To determine the associations between intrinsic factors and the presence of plantar fasciitis in Thai male conscripts
- To determine the associations between intrinsic factors and the average pain intensity during last week from plantar fasciitis in Thai male conscripts
- To determine the differences in lower-extremity kinematics between the subjects with and without plantar fasciitis during the stance phase of gait cycle in Thai male conscripts

1.4 Research Hypotheses

- There are associations between intrinsic factors and the presence of plantar fasciitis in Thai male conscripts.
- There are associations between intrinsic factors and the average pain intensity during last week from plantar fasciitis in Thai male conscripts.
- There are differences in lower-extremity kinematics between the subjects with and without plantar fasciitis during the stance phase of gait cycle in Thai male conscripts.

1.5 Operational definition

1.5.1. Extrinsic factors

Extrinsic factors are those that are from the outside of the body (environment-related factors). These include competition level, skill level, shoe type, ankle bracing, and playing surface (28).

1.5.2. Intrinsic factors

Intrinsic factors are those that are from within the body (person-related factors) (28). The present study aimed to investigate the association between intrinsic factors and the presence of plantar fasciitis among Thai male conscripts who were under similarly extrinsic factors. The intrinsic factors could be categorized into 3 factors consisting of individual, anatomical, and biomechanical factors (7).

Individual factors included age, body mass index (the calculation form of the weight and height), physical activity level, and psychological distress (depression, anxiety, and stress) (29, 30).

Anatomical factors were composed of the bony factors and the soft tissue factors. Bony factors involved with the lower-extremity alignment that could only be altered surgically such as femoral anteversion or retroversion, quadriceps angle, tibial torsion, and foot structure. And the soft tissue factors related to the range of joint motion; the involved structures were muscle, tendon, and ligament such as the muscle flexibility, muscle strength, and ligamentous laxity (12).

Biomechanical factors were defined as joint-related factors that interact with the forces, moments and kinematics in and around the joints (31). In addition, these included the quality of movement or movement coordination that referred to the biomechanics of the lower extremities, trunk and arms in relationship with its surrounding during physical activities (32).

1.6 Scope of the study

The etiology of plantar fasciitis is probably multifactorial. Various factors which are commonly used to explain the overload condition related with running or training can be classified into two categories consisting of intrinsic and extrinsic factors (6, 7). To clearly understand the intrinsic factors including anatomical and biomechanical factors associated with plantar fasciitis, the present study will conduct among the male conscripts with younger age ranged between 18 and 26 years; therefore the environmental or extrinsic factors of each subject are quite similar. The other main reason to study among this specific population is due to their overload weight-bearing trainings which could induce more injury from plantar fasciitis. The previous study of Scher et al., collected the total numbers of plantar fasciitis patients from the Defense Medical Epidermiology Database during the years 1998 to 2006 among military recruits in the United States; the authors revealed that the overall incidence rate of military recruits was 10.5 per 1000 person-years (10). Additionally, we recently conducted a survey study among male conscripts (339 subjects) and found that the prevalent rate of plantar fasciitis was 23.6%. The conscripts reported their pain at foot region with the highest rate of 20.4% when compared with other regions including lower leg region of 16.5%, upper leg region of 14.5%, ankle region of 12.7%, and knee region of 9.4%

respectively (Appendix A). The conceptual framework from the present study is shown in Figure 1.2.

1.7 Expected benefit and application

The results from the present study could provide epidemiological information about the risk factors of plantar fasciitis with regards to the anatomical and biomechanical variables of lower extremity during basic military training in Thai male conscripts. In addition, the kinematics differences of lower extremity between individuals with and without plantar fasciitis were determined. The knowledge was useful to prevent overuse injuries of lower extremity from military training program.

CHAPTER 2

LITERATURE REVIEW

2.1 Anatomy and functions of plantar fascia

Plantar fascia is a fibrous structure which consists of dense well-organized collagen triple helix with minimal elastic fibers (23). It originates at medial tubercle of the calcaneus and extends to each digit in three distinct bands including medial, lateral and central bands. Medial and lateral bands are virtually thin structures that provide the partial origins of the flexor hallucis brevis and the abductor digiti minimi respectively (33). Regarding the central band, it originates from the medial calcacaneus and obtains some fibers from the Achilles tendon. With 12 to 29-mm width of triangular shape, it expands cover the plantar surface of the foot and provides the partial origin of flexor digitorum brevis. It divides into five separate bands at mid-metatarsal level; with each band proximally to the metatarsal head, they divide again into superficial and deep tracts (34). For superficial tract, they insert into the skin while the deep tract continue longitudinally to reach medial and lateral sides of each digital flexor (35). Central band of plantar fascia is the most structural and functional structure of the plantar fascia and often used to explain the pathomechanism of plantar fasciitis (Figure 2.1) (24).

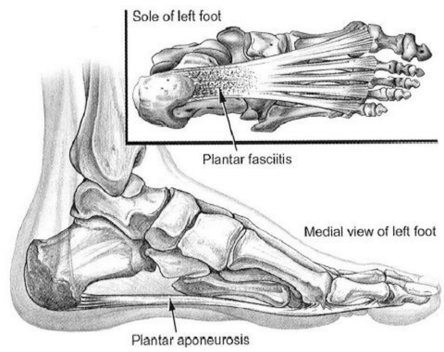


Figure 2.1 The anatomy of plantar fascia

Due to the triangular shape of plantar fascia (Figure 2.2), it functions to support medial longitudinal arch of the foot during static stance and gait. To understand the loading of plantar fascia, the foot acts as a truss which includes a tie-rod or plantar fascia and the beams or osseous structures of the longitudinal arch which include medial three metatarsals, navicular, cuneiforms, talus, and calcaneus bones (33). During static stance, the superior border of the medial arch i.e. osseous structures are under compression, while the inferior surface i.e. plantar ligaments and plantar fascia are placed under tension. Plantar fascia acts as a spring or rope to bind two beams i.e. heel and forefoot and provides primary passive support of the medial arch (24). The tension of plantar fascia limits an elongation of medial arch or prevents the arch from collapsing during both static stance and dynamic loading (33).

Figure 2.2 The triangle shows the truss formed by the calcaneus, midtarsal joint, and metatarsals bone

Considering the function of plantar fascia during gait, it prevents excessive medial longitudinal arch elongation together with eccentric contraction of toe flexors muscles during the midstance subphase. An increased tension of plantar fascia provides the arch stability and assists re-supination of the foot during the late midstance and propulsive subphases (24). At toe off, the foot functions as rigid lever arm via windlass mechanism or arch-raising mechanism. Extension of the 1st metatarsophalangeal joint pulls the plantar fascia which wraps the plantar side of metatarsal head into downward movement. The plantarflexed position of the rays raises the medial longitudinal arch and increases stability of midtarsal joint (Figure 2.3) (36). Thus, the plantar fascia plays an important role in supporting the arch under different loading condition and assisting in toe off (36). The previous in-vitro and in-vivo studies focused on the function of plantar fascia and its role to support medial longitudinal arch. For example, Wright and Rennels conducted an experiment design using human cadaveric feet to measure the arch elongation under different loading conditions. They found that the higher load condition resulted in the more flattening of the arch and the loss of plantar fascia elasticity which was calculated from a stress-strain curve (37). Similar to the other, the authors concluded that the plantar fascia was the most passive structure to maintain medial arch compared with other ligamentous structures such as spring ligament, short, and long plantar ligament. They reported that the resection of plantar fascia led to 25% reduction of its original arch stiffness which was the greatest reduction compared with the others. Anyways, after the resection of four combined passive structures, the arch stiffness remained 63% of its original stiffness (38). The in-vitro studies supported the plantar fascia as the main arch stability during loading; however, these studies could not determine the contribution of extrinsic and intrinsic muscles of the foot which were vital to dissipate any loads on the foot and maintain arch length during the stance phase of walking. To address these limitations, the in-vivo studies were needed to measure additional supporting structures of the arch during loading.

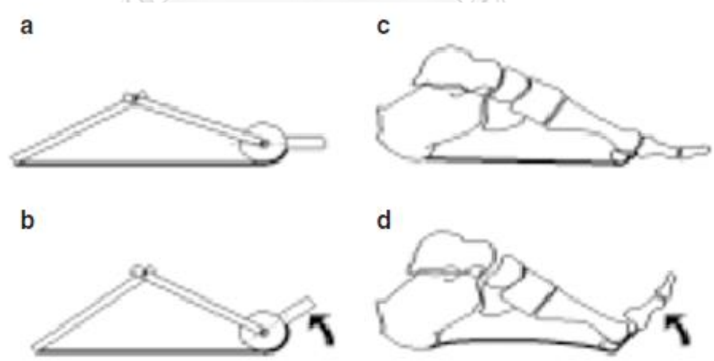


Figure 2.3 The starting position (a,c) and Windlass effect via an extension of 1st metatarsophalangeal joint (b,d)

Dynamic control of arch stabilizer

Dynamic stabilizers that contribute to the medial arch support include twelve extrinsic and nineteen intrinsic muscles. The leg muscles provide the strongest control of the foot during gait. They act as the force recruitment to propel the body forward as well as the control of smooth progression through the stance phase of gait cycle (24). The Gastrosoleus muscles are active to control eccentrically of the tibia over the foot during the midstance subphase and then to generate force for toeing off during the propulsive subphase. In addition to the Gastrosoleus muscles, other ankle plantarflexors especially tibialis posterior also acts to stabilize the medial arch during gait. Tibialis posterior is the strong invertor which is active to prevent excessive calcaneal eversion during the midstance subphase and provide the rigidity of the foot by locking the midtarsal joint during the late stance and propulsive subphases (24). The previous in-vitro study (38) also supported that the tibialis posterior acts as the main arch stabilizer under the 350 N and 700 N loads. Similar to the in-vivo study of Basmajian and Stecko, the authors reported that the arch stabilier muscles were less active under the smaller load; thus the passive structures especially the plantar fascia were more active during this condition. When the loading condition up to 400 pounds, the muscle supports were primary facilitated instead. The results supported the function of plantar fascia and arch stabilizer muscles under each different loading condition (39).

2.2 Epidemiology of plantar fasciitis

Plantar fasciitis is an overuse syndrome that affects up to 15% of all adult foot complaints and 10% of the population over the course of a lifetime. It accounts for 8-10% of running or training related injury and 80% of heel pain (1, 2). Plantar fasciitis is the most common foot condition diagnosed by health care provider. It has been estimated that more than 1 million patients with plantar fasciitis seeking for professional care in each year (2, 3). Generally, plantar fasciitis is a degenerative condition found among the older aged population; anyways, the updated evidence found an increasing prevalence of heel pain among younger aged population who spent more times with overload weight-bearing activities especially in runners and military personnel. A prospective study among 166 runners found that 98 runners (59%) reported their lower limb overuse injuries, with the highest incidence of plantar fasciitis (30 runners, 31%) (40). An increasing number of activity-induced injuries which include plantar fasciitis become the main public health problem due to its frequent occurrence, resulting in an immobility and reduction of activity levels (41, 42).

In military environment, musculoskeletal training-related injuries are a major problem which leads to a loss of time from work and a high cost of treatment (41, 43). The recent study among 1,411 conscripts reported that 51% of the participants suffered from overuse injury with the most frequent rate at lower extremity (67%) followed by the back (18%) (8). The other study also documented that the most common mechanisms of injury were overuse injury and exacerbations of pre-existing condition of lower extremity respectively (44). The pre-existing condition includes the previous history of musculoskeletal injuries before the training which result in the sensitivity to aggravate more symptoms. The musculoskeletal overuse injury is commonly insidious onset and associated with repetitive weight-bearing activities; while other injuries such as contusions, blisters and laceration are acute onset and not included in the musculoskeletal problem (44). The previous studies found the high incidence of lower-extremity overuse injuries ranged from 19% to 79% among military population (8, 13).

During military training, running is the primary mode of maintaining aerobic fitness; however, it is the main cause of overuse injury often seen in the military personnel. Increase in running intensity and mileage has been contributed to the injuries (8, 41). In addition to the running, other activities related to the training such as load carriage, long distance walking, prolong standing, and wearing of combat shoes may also attribute to the lower-extremity injuries (8, 41). The previous studies found that the workers with mostly time of prolong weight-bearing activities increased the risk of plantar fasciitis; anyways the evidence about the prevalence of plantar fasciitis among military recruits is limited (9, 45).

The previous reviews of military training-related injuries clearly reported the higher rate of injury associated with vigorous weight-bearing activities; and plantar fasciitis was found to be the five most commonly diagnosed injuries (41, 44). The study of Scher et al. collected the total numbers of plantar fasciitis patients from the Defense Mediacal Epidermiology Database during the years 1998 to 2006 among military recruits in the United States; the authors revealed that the overall incidence rate of military recruits was 10.5 per 1000 person-years and when compared with other recruits i.e. Navy, Air force, and Marine, the highest rate was found among the Army recruits (14.8 per 1000 person-years) (10). Our recent study among army recruits (339 subjects) from each military training unit in Bangkok found that the prevalent rate of plantar fasciitis was 23.6%. Moreover, the conscripts reported their pain at foot region with the highest rate of 20.4% when compared with other regions including lower leg region of 16.5%, upper leg region of 14.5%, ankle region of 12.7%, and knee region of 9.4% respectively (APPENDIX A).

2.3 Clinical presentation of plantar fasciitis

Plantar fasciitis is a common cause of chronic plantar heel pain which is often results from the overuse injury of plantar fascia at its origin on medial calcaneus. Diagnosis of plantar fasciitis is based on physical examination and patient history (4). Most patients have medial heel pain at the origin of plantar fascia which is gradually onset due to repetitive force in weight-bearing position. They typically complain their first-step pain in the morning or after non-weight bearing position for prolonged time; however, the symptom will be gradually decreased after walking for a few steps. Moreover, heel pain is aggravated after prolonged standing, prolonged walking, barefoot walking, tip-toe walking, and stair climbing (2, 3). On physical examination tests, the findings generally reveal that patients' sensations are intact. Patients with moderate-to-severe heel pain may avoid shifting weight on the painful foot or walk with antalgic gait. Palpation on medial plantar calcaneus region will elicit stabbing or sharp pain, radiating into the arch of the foot (4). The nature of pain from plantar fasciitis is not usually disabling; however, it can lead to the reduction in both every day and sporting activities (5).

Although plantar fasciitis is the most common cause of plantar heel pain, the differential diagnoses are needed to exclude other causes from bone, soft tissue, nerve, or systemic disease as described in table 2.1 (46).

Table 2.1 Differential diagnoses of plantar heel pain

Source	Pathology	Clinical characteristics
Bone	Calcaneal stress fracture	Diffuse heel pain which is aggravated immediately with any weight bearing activities
Bone	Apophysitis of the calcaneus	Heel pain which is elicited by squeezed test and also aggravated by weight bearing activities without any sign of inflammation
Bone	Osteomyelitis	Inflammation and swelling around the area of infected bone
Soft tissue	Fat pad atrophy	Heel pain which is centrally located and not presented during the first step in the morning
Soft tissue	Plantar fascia rupture	Acute onset of heel pain which is followed by ecchymosis at the origin of plantar fascia
Soft tissue	Calcaneal bursitis	Posterior heel pain with the sign of inflammation
Nerve	Nerve entrapment	Numbness and tingling pain over the heel, a positive finding of Tinel test
Nerve	L5-S1 nerve root compression	Positive finding of straight leg raising (SLR) test
System disease	Tumor	Constant heel pain which is not relieved during rest or non weight-bearing period

2.4 Pathomechanics of plantar fasciitis

The plantar fascia consists of dense well-organized collagen fibers with minimal elastic fibers (23). Considering the mechanical properties of plantar fascia, the elastic fibers are theorized to allow arch elongation during normal loading or arch deformation under excessive loading of plantar fascia; while the collagen fibers are theorized to increase tension of plantar fascia under arch elongation or deformation (37). These histological findings supported that plantar fasciitis is due to repetitive microtrauma at the proximal attachment of plantar fascia from prolonged or overload weight-bearing activities. The constant loading inhibits the normal repair process, resulting in collagen disorganization and collagen fragmentation respectively (Figure 2.4). These degenerative changes lead to the perifascial odema and then mechanical adaptation; thus the plantar fascia elasticity is reduced and unefficient to resist tensile loading (14, 17).

Based on the concept of overload condition as shown in Figure 1.1, the change in mechanical properties of the plantar fascia leads to the gradually anatomical alteration rather than acute transition from normal to abnormal. The anatomical alteration, for example, ankle plantarflexors inflexibility and weakness may affect the functional biomechanical deficit which involve the abnormal gait adaptation (17). It has been postulated that there is anatomical connection between Achilles tendon and plantar fascia; thus the tension in Achilles tendon may increase tensile stress of plantar fascia (22). During the midstance subphase of the gait cycle, the inflexibility of Gastrosoleus muscles causes the excessive midfoot pronation which is due to a compensatory mechanism from a lack of ankle dorsiflexion movement (1, 3, 23). Regarding to the propulsive subphase, the excessive foot kinematics affect the inefficient recruits of ankle plantarflexors, resulting in an arch instability during gait and the more tension force at the origin of plantar fascia as well (21). Abnormal foot biomechanics such as excessive foot pronation may lead to the functional change of lower-extremity kinetic chain that could provide the path of least resistance to motion and the site of compensation for various proximal structures such as lower extremity muscles, ankle joint, knee joint, and hip joint (24). In addition, the abnormal movement control of hip musculature, especially hip abductors also cause abnormal lower-extremity biomechanics such as femoral internal rotation, tibial internal rotation, subtalar pronation and excessive midfoot pronation as well, resulting in the repetitive injuries of distal part and more tensile stress of the plantar fascia during walking (25, 26). The latter process is described as negative feedback cycle of the overload condition as presented in Figure 1.1.

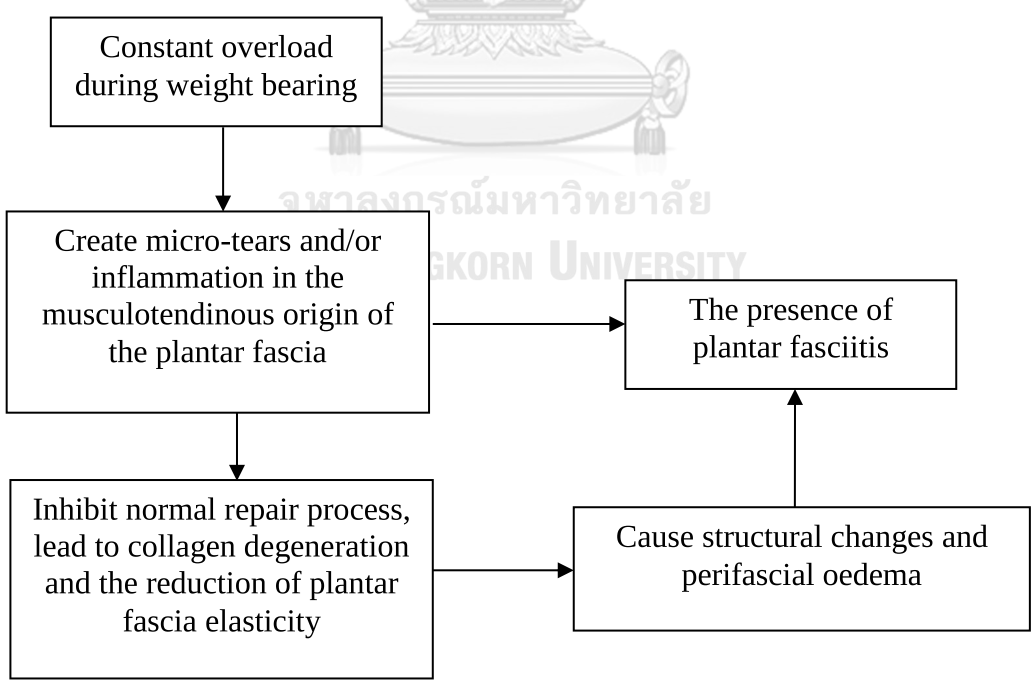


Figure 2.4 Pathomechanics of plantar fasciitis

2.5 Factors associated with plantar fasciitis

The etiology of plantar fasciitis is probably multifactorial. The condition is likely to occur in obese persons, working adults with sedentary life and young adults with intense physical activity as well (3, 6). Plantar fasciitis often results from the overuse injury of plantar fascia at its origin on medial calcaneus. Repetitive movement of walking and running can cause microtrauma of the fascia, leading to an acute inflammatory response and chronic degenerative condition or spur formation at medial heel (2). Plantar fasciitis has its impacts on the restriction of the ability to perform weight bearing activities in daily life, work, social and family functions (5). The various factors which are commonly used to explain the overload condition related with running or training can be classified into four categories consisting of individual, environmental, anatomical, and biomechanical factors (6, 7). The present study will conduct among the conscripts with younger age ranged between 18 and 26 years; therefore the environmental or extrinsic factors of each subject are quite similar.

2.5.1. Extrinsic factors

Regarding to the training-related injuries among military personnel, extrinsic or environmental risk factors are difficult to modify; the attributed factors may include the magnitude of running, load carriage as well as the wearing of combat boots (47, 48). The higher magnitudes or volumes of impact force as experienced during running or load carriage are a major risk factor for overuse injuries (47). Many previous studies showed an association between running volume and overuse injuries (7, 13, 44, 48). Adults commonly take an average of

10,000 steps; anyways, this dosage increases with running. The ground reaction force at the midstance subphase during running ranged from 1.5 to 5 times body weight among both military population and competitive runners (49). Even with a shorter run, ground reaction force and joint excursion are double in magnitude compared with walking, resulting in more tension stress on joints and soft tissues of the foot which include plantar fascia (18, 50). As described previously, the repetitive stress from overload condition leads to the structural change of plantar fascia (18). A number of studies among military recruits have demonstrated a dose-response curve in relation to running and other weight-bearing activities; the positive association is found between the presence of lower-extremity injuries and the frequency, duration, and total amount of training (13, 41, 44). Additionally, the less cushioning of combat boots is also the other contributed factor leading to the higher volumes of impact forces. The previous study compared the mechanical force between the combat boots and commercially available footwear; the results showed the higher peak impact force at heel region in the military boots (41). A shoe with higher impact force could absorb less shock; it consequently transmits more forces to the musculoskeletal system, leading to the injuries of lower-limb kinetic chain (41).

2.5.2. Intrinsic factors

a) Individual characteristics

Plantar fasciitis is a degenerative condition commonly found among adults with aged over 45 years old. Anyways, the update evidence found the high prevalence of the condition among younger adults whose activity related with high-load training or running which lead to the repetitive micro tear and the mechanical properties change of the plantar fascia as well (14). And for body mass index (BMI), many previous studies supported the strongly association between the overweight and the presence of plantar fasciitis (1, 51, 52). The higher BMI may lead to an additional stress to the plantar fascia which acts as the truss to support medial longitudinal arch. The tensile force from body weight directs downwardly to the metatarsal head and the heel; thus the tension within the fascia is increased especially at its proximal attachment which leads to the periosteal lifting and calcaneal spur formation as well (51).

Regarding to the training-related injuries, the previous studies found the low level of past physical activity and previous musculoskeletal injuries to be attributed factors of lower-limb overuse injuries among military population (8, 48). It has been suggested that the patients with previous injuries especially at foot and ankle regions may be more likely to experience re-injury due to the change of tissue properties from the original tissue after repaired process, resulting in the susceptibility to re-injury during vigorous physical training (14). The previous data from epidemiological studies among the patients with plantar fasciitis reported the reoccurrence of injuries ranging from 21 to 70% (14, 18). The specific regions of lower extremity should be included for further studies to determine the association of the previous musculoskeletal injuries and the presence of overuse injuries including plantar fasciitis (14). The recent study also documented the association between the low level of past physical activity and subsequent overuse injuries (8). Mostly military training emphasizes on weight-bearing activities such as running, marching, and load carriage which exert more load on lower limbs (13, 41). The result from prospective cohort study found that the level of physical activity was a predictor for musculoskeletal injuries during intensive training (8). The high level of physical activity may result in the body adaptation to prevent overuse injuries when the conscripts are subjected to new strain; thus the untrained conscripts before military entry may overload their musculoskeletal structures and tissues more often than their active counterpart (8, 53-56).

b) Foot alignment

Generally, the foot functions as the shock absorption, body weight support, and the gait propulsion via its rigid lever arm during the late stance phase. At initial contact, the foot is in supinated position and then immediately changes into pronation through the midstance subphase. The foot increases its mobility for shock absorption within this period. When it reaches maximum pronation at the late stance, the foot becomes supinated to increase the stability for propulsion (24). The forces generated during each position may contribute the tension of the plantar fascia which acts as the main medial arch support of the foot (24). Abnormal foot function both excessive pronation and rigid supination lead to the more tensile stress of the fascia at its proximal attachment (24). Structural deformity of the foot such as forefoot varus and rearfoot varus may contribute an excessive foot pronation during static stance and dynamic position (24, 57). The flattening arch from the foot hypermobility can increase the stress of plantar fascia via an elongation of soft tissue within the foot (24). A forefoot varus deformity is an abnormal inverted position relative to the rearfoot which was commonly measured in prone position. The compensated forefoot varus results in the more subtalar pronation that allows the medial metatarsal head to contact the floor (58). Similar to the compensated rearfoot varus, the excessive subtalar movement brings the medial heel to contact the floor as well (57, 59, 60). During gait, an excessive pronation of the midfoot causes the arch instability or insufficient windlass mechanism during the late stance that is needed for efficient propulsion of walking (24). The altered timing during this period may disrupt the synchronous movement of the foot, tibia, femur, and pelvic regions which lead to any injuries within the kinetic chain of lower extremity (57, 61).

In addition, the presence of plantar fasciitis may result from an inability of the foot to dissipate force during the midstance which is commonly found among the patients with rigid pes cavus foot. Decreased shock absorption results from the reduction of distance between metatarsal head and the calcaneus; the plantarflexed first ray of high-arch foot leads to an increased tensile stress at the origin of plantar fascia (24). The uncompensated rearfoot varus and compensated forefoot valgus may contribute the movement of subtalar joint in a more supinated position which increase more load on the lateral side of the foot (57, 59, 60). During gait, the rigid foot leads to an inability to elongate the plantar fascia for the shock absorption in the midstance, resulting in the compression injuries or stress fracture of the foot (24).

The previous studies investigated the association between the foot alignment and the presence of plantar fasciitis. For example, the study of Rome et al., the authors compared the difference of the navicular height between case and control groups and found no significant difference (14). The other two studies investigated the differences of foot posture using foot posture index (FPI) to classify into normal foot, pronated foot, and supinated foot. One study found that the case group had more pronated feet than the control group significantly (52); while the other showed no significant difference among runners (51). The anatomical study of Pohl et al. found that the runners with a history of plantar fasciitis had significantly higher medial longitudinal arch angle than the control group. The authors concluded that the presence of plantar fasciitis is related with flatten medial longitudinal arch; while the rearfoot alignment in standing position showed no difference between groups (18). Similarly to the study of Ribeiro et al., the authors found the significantly arch flattening in the runners with plantar fasciitis more than the runners without symptom; anyway there was no difference in rearfoot valgus angle during standing position (20). Due to the different techniques, the conflicted results among the studies were found. The foot measurement in non weight bearing is vital to determine the forefoot alignment while the measurement in weight bearing position is generally used to categorize the compensated pattern of individual abnormality (57). Commonly, the mechanism of overuse injuries during running or walking is explained by the rearfoot structure including its kinematic variables as well; the forefoot structure has been largely overlooked in the research setting (57). Regarding to the previous studies, one study inferred that only 4° of forefoot varus could lead to the significant greater hip flexion and rearfoot eversion during walking when compared with the subjects without forefoot varus (58). The abnormality has also been linked with the hip injuries among older-aged adults. Holt and Hamill explained that forefoot varus abnormality related with the occurrence of prolong midfoot pronation during heel-off and toe-off subphase of the gait cycle, resulting in any injuries of the proximal segment such as hip and knee pain (62). The observation analysis among prolong standing workers implied that the patients with plantar fasciitis had more forefoot pronation during gait than control group significantly (45). Anyway, there is a lack of information about the forefoot abnormality which was measured in weight-bearing position and the presence of plantar fasciitis.

c) Ankle plantarflexors performance

As described previously, foot pronation has often been implicated with the presence of plantar fasciitis. It has been postulated that the occurrence of foot pronation may be due to the structural abnormality or compensatory mechanism from a lack of ankle dorsiflexion (1, 16). During gait, the Gastrosoleus muscles are active to control eccentrically of the tibia over the foot during the midstance subphase and then to generate force for toeing off during the propulsive subphase. Thus the inflexibility of Gastrosoleus muscles causes the excessive dorsiflexion at midfoot instead of ankle joint, resulting in the more tensile stress of plantar fascia (1, 16, 52). In addition, the poor strengths of Gastrosoleus also lead to an insufficiency to generate their concentric force for gait propulsion. The plantar fascia then increases its tension to support arch instead (17, 63). Considering other ankle plantarflexors especially tibialis posterior, it is the strong invertor which is active to prevent excessive calcaneal eversion during the midstance subphase and provide the rigidity of the foot by locking the midtarsal joint during the late stance and propulsive subphases (24). Tibialis posterior dysfunction leads to an excessive dorsiflexion of midfoot as well as the late supinated midfoot to provide the arch stability during gait, resulting in the more tension of passive structure to enhance the foot rigidity (64, 65).

The previous studies investigated the role of ankle plantarflexors to the presence of plantar fasciitis. Considering the flexibility of Gastrosoleus muscles, the study of Irving et al. measured the degrees of ankle dorsiflexion using the lunge test. The authors found no significant difference of the mean angles between chronic plantar heel pain group and control group. They inferred that decreased ankle dorsiflexion might not play an important role to the presence of plantar heel pain (52). Contrary to the result from other two studies, for example, the study of Riddle et al. using a matched case-control design found that the cases had ankle dorsiflexion less than 5 degrees and 10 degrees respectively when compared with the control subjects. The measurement was done in prone position with knee extension (1). The other study measured in supine lying with both 90° knee flexion and knee extension; the authors found the numbers of cases with ankle limitation significantly more than the control in both knee positions. The normal degrees of ankle dorsiflexion with knee extension were 10 degrees and with 90° knee flexion were 15 degrees (16). The clinical practice guideline of plantar fasciitis management recommended that clinician should measure the degrees of ankle dorsiflexion as the predisposing factors to the presence of plantar fasciitis (2, 3). With regards to the muscle strength, one study found that the cases had decreased ankle plantarflexors strength than the control which was measured by the peak torque of Cybex dynamometer (17). The other study also implied that the patients with plantar fasciitis limited their ability to repeat the standing heel raise task (65). The measurement of tibilalis posterior muscle size from magnetic resonance images (MRI) found that the cases had smaller cross sectional area (CSA) than the control (21). The study of Allen and Gross measured the toe flexor strength with dynamometer; there was significantly weaker in the subjects with plantar fasciitis than the control (63). Thus the extrinsic leg muscles may play an important role to the tension of plantar fascia and related with the presence of chronic plantar heel pain.

d) First metatarsophalangeal joint motion

The repetitive microtrauma of plantar fascia from the overload weight-bearing activities causes the changes of its mechanical properties such as the collagen fragmentation and the loss of fascia elasticity which may lead to the loss of toe extension movement as well (63). Thus an additional arch support from plantar fascia via windlass mechanism is not effective enough to provide the foot stability; the tensile stress of plantar fascia is then increased and related with the presence of plantar fasciitis during excessive walking or running (18, 24). The previous studies examined the movement of first metatarsophalangeal joint from static physical examination and kinematic laboratory. To measure in non weight-bearing position, one study found a significant decrease in dorsiflexion of first metatarsophalangeal joint range of motion among the patients with plantar fasciitis when compared with the control subjects (Creighton and Olson, 1987) while the other study show no significant difference between group (63). The recent kinematics study (21) found that the patients with plantar fasciitis increased dorsiflexion of first metatarsophalangeal joint during walking when compared with the control subjects, similarly to the previous one (18). The greater extension during walking is enhanced by the ground reaction force during propulsion subphase; consequently the patients with plantar fasciitis may increase more movement to provide the foot stability from the reduction of plantar fascia extensibility (21, 66).

e) Lumbopelvic-hip function

The stabilization of trunk and pelvis are necessary to control the movement of lower extremity (25). The empirical evidence had suggested that the poor control of hip musculature was related with the lower-extremity overuse injuries (61, 67, 68). The core control of hip muscles especially hip abductors and hip external rotators are necessary to control the alignment of distal segment; they function to maintain the pelvic level and prevent excessive movement in femoral adduction and internal rotation during single-limb support of walking (25, 69). In addition, they affect the abilities of hamstrings and quadriceps muscles to either generate force or resist force of lower extremity during athletic movement (61). The poor recruitment of core hip muscles such as gluteus medius, gluteus minimus and gluteus maximus affect the stability of hip joint as well as the frontal, transverse and sagittal plane movement of distal lower limb (26, 70). There is growing evidence that proximal musculature dysfunction lead to the change of weight-bearing line to more medial side of each joint, resulting in an excessive internal rotation of the femur and tibia as well as more foot pronation (68). The subsequent movement from these changes is proposed to increase the activation of two-joint muscles which consist of tensor fascia latae, rectus femoris, and hamstrings muscles (61, 67). The subsequent tightness of tensor fascia latae and rectus femoris are due to the poor control of gluteus medius muscles. In addition, the more active of hamstring muscles which are due to the poor control of gluteus maximus may lead to hip hyperextension and abnormal anterior glide of femoral head during double-limb support of walking (25). An increased tightness of hamstrings contributes to the more flexion of the knee which then induces forefoot loading and limited ankle dorsiflexion, resulting in the tension stress of the plantar fascia (71).

Regarding to the proposed mechanism from foot to core dysfunction, an abnormal foot pronation may lead to the disruption of plantar fascia from excessive tension as described previously. In addition, it is coupled with excessive internal rotation of the tibia and femur, a knee valgus, and more anterior pelvic rotation. The consequent internal rotation of the femur causes its head to move backward against the posterior portion of the acetabulum which leads to the anterior tilting of pelvis (25, 67). The previous study showed the significant positive association between internal rotation of the leg and anterior pelvic tilt (r=0.58) (68). The alteration of pelvic alignment is hypothesized to increase more strain of pelvic and hip muscles which are composed of iliopsoas, piriformis, and gluteal muscles. There is subsequent narrowing of the greater sciatic notch due to the anterior rotation of pelvis, resulting in sagittal plane wedging of intervertebral discs as well as the more strain of lumbosacral and sacroiliac joints (59, 72).

Despite there was the strong theoretical basis linking foot function to biomechanical dysfunction of the lower limb and consequent injuries in the previous studies, the empirical support is still lacking (61). Considering the hip musculatures related with the presence of plantar fasciitis, the previous three studies investigated the role of hamstrings tightness to the presence of plantar fasciitis. The study of Harty et al. found that the patients with plantar fasciitis had significantly more popliteal angle than the control subjects. The more popliteal angle represents the more knee flexion angle which contributes to the presence of hamstrings tightness. The authors also investigate the association between the forefoot loading and increased knee flexion angle; the results show that an increased knee flexion from 0° to 20° and from 20° to 40° had significantly increase forefoot loading. The prolonged forefoot loading may induce the activation of windlass mechanism, resulting in repetitive injury to the plantar fascia during each step of walking (71). Similarly to the other two studies, one study used popliteal angle to clarify the tightness of hamstrings; the results showed that there were the numbers of case with hamstring tightness (knee flexion more than 20°) 8.7 times more than the control subjects (73). The other study classified the persons with hamstring tightness using straight leg raising (SLR) testing. The authors concluded that the cases had the degrees of hip flexion significantly less than the control subjects. They also evaluated the diagnostic power of the SLR test with the method of ROC curves and the test showed 94% of sensitivity and 82% of specificity. The persons with hip flexion less than 80° were considered to have the tightness of Hamstrings (16).

f) Lower-extremity alignment

Anatomical factors associated with overuse injuries are categorized into bony factors and soft tissue factors (12, 32, 74). This topic will explain the bony factors which related to the bony alignment of lower extremity; these factors can be altered with only surgical that is not recommended for clinical setting. Anyways, an extensive physical examination should include these measurements due to their association with the overuse injuries (12, 32). These factors are composed of excessive femoral anteversion, static quadriceps angle (Q angle), abnormal tibiofemoral angle in frontal plane (Genu valgus/Genu varus), genu recurvatum, leg length inequality, excessive tibial torsion, rearfoot varus/valgus position, and forefoot varus/valgus position (12, 32). The previous studies revealed that the excessive foot pronation causing from either structural or functional could lead to the presence of plantar fasciitis. The compensation from this structural abnormality could enhance the kinematic change of lower extremity as described previously (57, 59, 60). Regarding to the abnormality of proximal structure, for example, an excessive femoral anteversion may enhance the internal rotation of the lower extremity and result in the gait compensation with toe-in movement (25). These changes lead to the more loading on the forefoot which could induce more tension of the plantar fascia during the propulsive subphase. For abnormal knee alignment such as genu recurvatum or knee hyperextension, it is often associated with excessive movement of ankle plantarflexion, hip extension, and posterior pelvic tilt (25); therefore the inflexibility of Gastrosoleus may occur and then increase more tension of the plantar fascia (40). And for abnormal in frontal plane, Genu valgus increases more compressive force on lateral side and more tensile stress on medial side of the knee which may induce more pronation of the foot. While genu varus increases more compressive force on medial side and more tensile stress on lateral side of the knee which may induce more supination of the foot (25). Considering an excessive external tibial torsion, it may be due to the compensation from excessive femoral anteversion; the individual attempts to correct toe in by lateral deviation movement of the foot while maintaining femoral internal rotation. When this abnormality is present, the foot pronation should not be corrected in clinical setting (25). For the quadriceps angle, it represents the line of resultant force of the quadriceps; the larger angle produces excessive lateral forces on the patella. Q angle can be increased by foot pronation, external tibial torsion, genu valgus, genu recurvatum and excessive femoral anteversion (25). Regarding to the leg length discrepancy, it has disruptive effects on gait, posture, and ambulation. The explanation from the previous study concluded that the abnormality might contribute to the development of plantar fasciitis by producing the more pronation on the shorter side (12). While the other study indicated that there was a strong correlation between a longer limb and unilateral plantar fasciitis (75). The further investigation is needed to perform.

The previous studies revealed the association between abnormal alignment and the presence of overuse injuries among runners and military population. The previous studies among military found that the high arch, low arch, genu valgus, and larger quadriceps angle were related to the presence of lower-extremity injuries (13, 41). While the incidence of plantar fasciitis among the runners was associated with genu varus; the results found the genu valgus to be a protective factor of plantar fasciitis (40). The conflict evidence with the previous retrospective study among runners with plantar fasciitis revealed that the numbers of patients with genu valgum was higher than genu varus (51). There is a lack of information about the anatomical abnormality in the more proximal structure and the presence of plantar fasciitis.

2.6 Kinematic assessment of individuals with plantar fasciitis

Extensive research has been conducted previously to determine the foot posture and range of motion among the patients with plantar fasciitis. Anyways, there has been limited study on the mechanical effects of plantar fasciitis to the lower extremity during gait. The previous studies implied that the patients with plantar fasciitis generally shorten their stride length in the affected side to reduce weight bearing on the painful foot (17). Compared with normal kinematics, the patients may decrease hip extension angles during the midstance subphase of the gait cycle which leads to the poor control of the tibia over the foot (25). This subsequent gait adaptation also affects the tightness of posterior leg muscles i.e. Hamstrings and Gastrosoleus muscles. As previously described, the shorten length of Hamstrings limits knee movement which is due to the knee stiffness in flexion, resulting in the more forefoot loading (71). Consequently, the ankle plantarflexors are tightness and limit ankle dorsiflexion during the heel-off subphase. The movement at least 10 degrees of ankle dorsiflexion is needed to provide the smooth motion of the tibia over the foot (1, 16). The previous anatomical studies found that the limitation of ankle dorsiflexion could enhance tensile stress of the plantar fascia which is due to the compensatory movement at midfoot, resulting in an excessive foot kinematics (1, 15).

The previous two studies used motion analysis to determine the kinematic changes of multi-segment foot during walking and running among the patients with plantar fasciitis (21, 27). This review will focus on the stance phase of gait kinematics. The study of Chang et al. compared the rearfoot and forefoot kinematics between plantar fasciitis feet and healthy feet with the constant walking speed of 1.35 m/s. Considering the rearfoot motion, it positions inverted during the initial contact; then it becomes everted in the midstance subphase and reaches the maximum eversion at about 80% of the stance phase. The immediately change into the stability position causes the inverted movement during the propulsive subphase. The total rearfoot motion is mainly in frontal plane with the average angle of 6.2 degrees. The result showed that the patients increased their total rearfoot motion significantly when compared with the control subjects. Regarding to the forefoot motion, it positions plantarflexed during the initial contact; then it becomes dorsiflexed in the midstance subphase and reaches the maximum dorsiflexion at about 80% of the stance phase. The immediately change into the stability position causes the plantarflexed movement during the propulsive subphase. The total forefoot motion is mainly in sagittal plane with the average angle of 9.4 degrees. The result showed that the patients increased their total rearfoot motion significantly when compared with the control subjects (21).

Consequently, an excessive foot kinematics among the patients with plantar fasciitis induces more pronation of the midfoot during the midstance subphase which leads to the limitation of tibial movement over the foot in the late stance phase. Thus the successive motion may produce more internal rotation of the proximal structures i.e. tibia and femur. And due to the limitation of ankle movement, the patients also compensate their movement by increasing knee hyperextension which could then stimulate the excessive anterior tilt of ipsilateral pelvis during the single-limb support (25).

2.7 Lower-extremity physical examination

Plantar fasciitis is one of the most overuse injuries among runners or individuals with prolong weight-bearing activities. It has been proposed that plantar fasciitis may arise from abnormal muscular or structural impairments, resulting in the change of lower kinetic chain and repetitive microtrauma at the proximal attachment of plantar fascia. Although many previous studies reported the specifically anatomical measurement of lower extremity, little information existed on the comprehensive selection of anatomical factors related with plantar fasciitis. The clinicians should perform an extensive physical examination to investigate the definite impairments of each patient which generally include the lower-extremity assessment such as structural alignment, muscle performance, range of motion, and quality of movement.

The previous studies recommended the essential lower-extremity examination to determine the impairments related with overuse injuries including plantar fasciitis (3, 32, 74). The tests are composed of pelvic angle, leg length measurement, lumbopelvic-hip function, femoral anteversion, Q angle, tibiofemoral angle, genu recurvatum, tibial torsion, foot alignment, ankle plantarflexors performance, ankle dorsiflexion and 1^{st} metatarsophalangeal dorsiflexion range of motion assessment. The details of each measurement from the previous studies will be described as the following. The pilot study was also conducted to determine the intra-rater and inter-rater reliability of each test. Among the tests with continuous outcome, the results showed the intraclass correlation coefficient for intra-rater reliability ($ICC_{3,1}$) ranging from 0.52 to 0.96 and intraclass correlation coefficient for inter-rater reliability ($ICC_{2,1}$) ranging from 0.51 to 0.92 as presented in Appendix I. And for the tests with categorical outcome, the results showed the Kappa coefficient ranging from 0.82 to 0.95 for intra-rater reliability and ranging from 0.76 to 0.91 for inter-rater reliability. According to the conclusion of Portney and Watkins, the coefficient below 0.50 represents the poor reliability; from 0.50 to 0.75 indicates the moderate reliability; and above 0.75 means the good reliability (76).

2.7.1. Pelvic angle

In clinical practice, the most common technique to assess pelvic asymmetry in the patients with lower-extremity overuse injuries is the inclination angle between anterior superior iliac spine (ASIS) and posterior superior iliac spine (PSIS) using PALM inclinometer. The previous studies reported that the intraclass correlation coefficient for intra-rater reliability (ICC $_{3, k}$) ranged from 0.87 to 0.98 and the intraclass correlation coefficient for inter-rater reliability (ICC $_{2, k}$) ranged from 0.86 to 0.97 (77-79). The standard error of measurement (SEM) and minimal detectable change (MDC) were 1.1 and 2.5 degrees respectively (79). When compared with the radiographic measurement, the result found the intraclass correlation coefficient of 0.93 (77).

2.7.2. Leg length measurement

Leg length is commonly measured using both direct and indirect methods. The tape assessment for direct method showed the ICC (3,k) ranging from 0.98 to 0.99 and the ICC (2,k) ranging from 0.87 to 0.91. The standard error of measurement (SEM) ranged from 0.29 to 0.44 cm (80, 81). When compared with radiographic measurement, the result found the intraclass correlation coefficient of 0.75 (80). Regarding to the lifting technique with 3.2 mm boards for indirect method, it showed the Kappa coefficient ranging from 0.98 to 0.99 for intra-rater reliability and the Kappa coefficient ranging from 0.84 to 0.87 for inter-rater reliability (80, 82). When compared with the radiographic measurement, the result found the intraclass correlation coefficient of 0.93 (80).

2.7.3. Lumbopelvic function

According to the recommendation from the previous studies about the anatomical factors associated with overuse injuries, the assessment of Lumbopelvic function should include the core hip strengths, the quality of trunk and pelvic movement, and the length of hip muscles (32, 83). For the core hip strength, the handheld dynamometer measurement of hip external rotators had ICC (2,2) of 0.79, ICC (3,2) ranging from 0.71 to 0.97, and SEM of 2.4 kilograms for inter-rater reliability (32). The measurement of hip abductors had ICC (2,2) of 0.85, ICC (3,2) ranging from 0.59 to 0.86, and SEM of 1.8 kilograms for inter-rater reliability (32). To measure the quality of movement, the lateral step down test had Kappa coefficient of 0.67 for both inter-rater and intra-rater reliability (32). Regarding to the length of hip muscles measurement, the Thomas test for iliopsoas length had ICC (2,1) of 0.52, ICC (3,1) ranging from 0.60 to 0.71, and SEM of 1 degree for inter-rater reliability (Peeler and Anderson, 2007). The modified Thomas test for quadriceps length had ICC (2,2) of 0.91, ICC (3,2) ranging from 0.90 to 0.93, and SEM of 3.8 degrees for inter-rater reliability (32). Similarly test for the tensor fascia lata length, it had ICC (2,2) of 0.97, ICC (3,2) ranging from 0.90 to 0.99, and SEM of 2.1 degrees for inter-rater reliability (32). The straight leg raising (SLR) test for Hamstring length had ICC (2,k) ranging from 0.61 to 0.88, ICC (3,k) ranging from 0.78 to 0.95, and SEM ranging from 13.16 to 19.31 degrees (16, 32, 78).

2.7.4. Lower-extremity alignment

The measurement of structural alignment includes the femoral anteversion angle, Tibiofemoral angle, genu recurvatum angle, quadriceps angle, and tibial torsion angle (32, 83). For the assessment of femoral anteversion angle, the Craig test had ICC (2,k) ranging from 0.45 to 0.83, ICC (3,k) ranging from 0.64 to 0.90, and SEM ranging from 3.1 to 4.5 degrees (32, 84). When compared with the radiographic measurement, the result found the ICC ranging from 0.67 to 0.69 (84). The measurement of quadriceps angle had ICC (2,k) ranging from 0.66 to 0.70, ICC (3,k) ranging from 0.77 to 0.87, and SEM ranging from 2.2 to 2.4 degrees (32, 78). To measure the genu valgus/varus, the assessment of Tibiofemoral angle in frontal plane had ICC (2,1) ranging from 0.51 to 0.58, ICC (3,1) ranging from 0.82 to 0.87, and SEM ranging from 0.7 to 2.1 degrees; to measure the genu recurvatum, the assessment of knee extension angle had ICC (2,k) ranging from 0.56 to 0.75, ICC (3,k) ranging from 0.88 to 0.97, and SEM ranging from 0.5 to 2.7 degrees (32, 74). The assessment of tibial torsion angle had ICC (2,k) ranging from 0.69 to 0.91, ICC (3,k) ranging from 0.88 to 0.97, and SEM ranging from 0.8 to 2.9 degrees (32, 74). When compared with CT scan, the result found the ICC of 0.72 (85).

2.7.5. Foot and ankle measurement

The classification of foot posture includes the measurement of rearfoot angle in weight-bearing position and medial longitudinal arch angle. The previous study reported the Kappa coefficient of 0.88 for inter-rater reliability and the coefficient of 0.94 for intra-rater reliability (86). In non weight-bearing position, the rearfoot angle measurement had ICC (2,1) of 0.86 and ICC (3,1) of 0.88 (86); the forefoot angle measurement had ICC (2,1) of 0.90 and ICC (3,1) of 0.97 (87). For ankle dorsiflexion measurement, the knee-extension postion had ICC (2,1) of 0.92, ICC (3,1) ranging from 0.78 to 0.97, and SEM of 1.6 degrees for inter-rater reliability; the knee-flexion position had ICC (2,1) of 0.86, ICC (3,1) ranging from 0.85 to 0.92, and SEM of 2.2 degrees for inter-rater reliability (32). Regarding to the first metatarsophalangeal joint angle, the assessment had ICC (2,1) of 0.82, ICC (3,1) ranging from 0.86 to 0.92, and SEM ranging from 1.4 to 2.0 degrees (88). The measurement of hallux valgus angle had ICC (2,1) of 0.92 and ICC (3,1) ranging from 0.78 to 0.98. When compared with the radiographic measurement, the result found the ICC of 0.98 (89).

2.7.6. Kinematic assessment

The marker placement set used for the present study were Helen Hayes marker set and multi-segment foot model (90). Regarding to the Helen Hayes marker set, it is a relatively simple set of external markers which was developed for time efficient video analysis of lower extremity kinematics. This marker configuration minimizes the patient preparation, data acquisition time and reduces the numbers of trajectories that must be tracked or edited. The adding of sacral marker and heel marker provide a more appropriate functional reference for the foot and pelvis; this set also includes the tibial and femur wands that allow the femoral and tibial rotations to be quantified for the first time (Motion, 2012). The multi-segment foot model that commonly used in the previous kinematics study among the patients with plantar fasciitis was the model of Leardini (21, 27). It is better to describe the motion of separate segment within the foot i.e. rearfoot, midfoot, and forefoot than the rigid-segment foot model. The model could also track the movement of tibia through multiple gait cycles in six degrees of freedom (90). The previous study reported the reliability of kinematics assessment from Helen Hayes marker set in the ankle angle, knee angle, hip angle, and pelvic angle measurement with ICC (2,1) ranging from 0.62 to 0.96, ICC (3,1) ranging from 0.57 to 0.96, SEM ranging from 0.3 to 2.7 degrees, and MDC ranging from 0.59 to 5.08 degrees

(91). For multi-segment foot model, the assessment of total foot motion in each segment had ICC (3,1) ranging from 0.71 to 0.94 (27).

2.8 Conservative treatment of plantar fasciitis

Multiple treatment modalities from conservative treatments to aggressive steps such as infiltrations and surgery are employed for plantar fasciitis (4). Conservative treatments include both chemical i.e. anti-inflammatory agents and physical treatments. The common physical modalities which consist of extracorponeal shockwave, ultrasound, and iontophoresis can reduce pain and improve function; however, the biomechanical prospective among these physical treatment is unclear. Based on the concept of overload condition as shown in Figure 1.1, the change in mechanical properties of the plantar fascia i.e. an arch deformation from repetitive microtrauma could lead to the functional biomechanical deficit which involves the abnormal gait adaptation. Thus the appropriate intervention for the treatment of plantar fasciitis should reduce more tension of the plantar fascia and prevent its mechanical adaptation. The previous kinematics studies found an immediate effect to the change of multi-segment foot kinematics after applying taping and foot orthotics in the uninjured subjects. For example, the study of Lin et al., (2013) compared the foot orthotics condition with barefoot condition during toe-off subphase; the authors found that the foot orthotics condition significantly decreased the maximum plantarflexion angle of the forefoot and increased the minimum medial longitudinal angle (arch height) than the other. These findings supported the use of foot orthotics for the treatment of plantar fasciitis by effectively reducing the windlass effect. Similarly to the kinematics study of the taping intervention, the previous study found that the low dye taping had an immediate effect to the significant reduction of medial arch angle which led to the higher arch during the toe-off subphase when compared with barefoot condition; anyways this continued effect was reduced after 48 hours of applying an intervention. The effect was short-lived and there was no conclusive finding about the kinematics change of more proximal joint during gait (92).

Although a few biomechanical studies after applying intervention were conducted, the several clinical trials had been done to investigate the effectiveness of taping and foot orthotics for the treatment of plantar fasciitis. Regarding to the foot orthotics, it is commonly used as a part of the conservative treatment for plantar fasciitis. As described in American clinical practice guideline, customized foot orthosis (CFO) and prefabricated foot orthosis (PFO) could be used to reduce pain and improve function for short-term (3 months) to long-term management (12 months) in the treatment of plantar fasciitis (2, 3). Anyways, our recent study found no significant difference among the CFO, PFO, and control groups in the pain reduction, functional disability of lower extremity, and foot function improvement at 1-month, 3-month and 6-month follow up.

Additionally, some previous studies supported the use of taping technique as an alternative to stabilize subtalar joint in neutral position and to stress off the plantar fascia (93, 94). From the evidence-based review, the authors reported the strong evidence in the effectiveness of low-dye taping to reduce pain at 1-week follow up while the reduction of functional ability of lower extremity was inconclusive (95). Likewise, the other study also found the significant pain reduction in the low-dye taping group when compared with the sham taping and no taping groups at 1-week follow up (96). Obviously, the several studies reported the reduction of pain intensity in the taping group while the functional disability of lower extremity was not changed during the follow-up period. The adverse effects from low-dye taping were reported in the previous studies such as the skin irritation from adhesive glue on the rigid tape as well as the limitation of joint motion in daily activity (93-96). Consequently, an elastic therapeutic tape becomes widely used by practitioners; it is a thin cotton fabric with acrylic adhesive that could reduce the skin irritation. After taping, the joint can maintain their range of motion and reduce pain by enhancing the skin lifting to promote normal flow of blood and lymphatic fluids (97). Further studies should be conducted to investigate the kinematics changes of lower extremity after taping among individuals with plantar fasciitis.

CHAPTER 3

GENERAL METHODOLOGY

3.1 Research framework

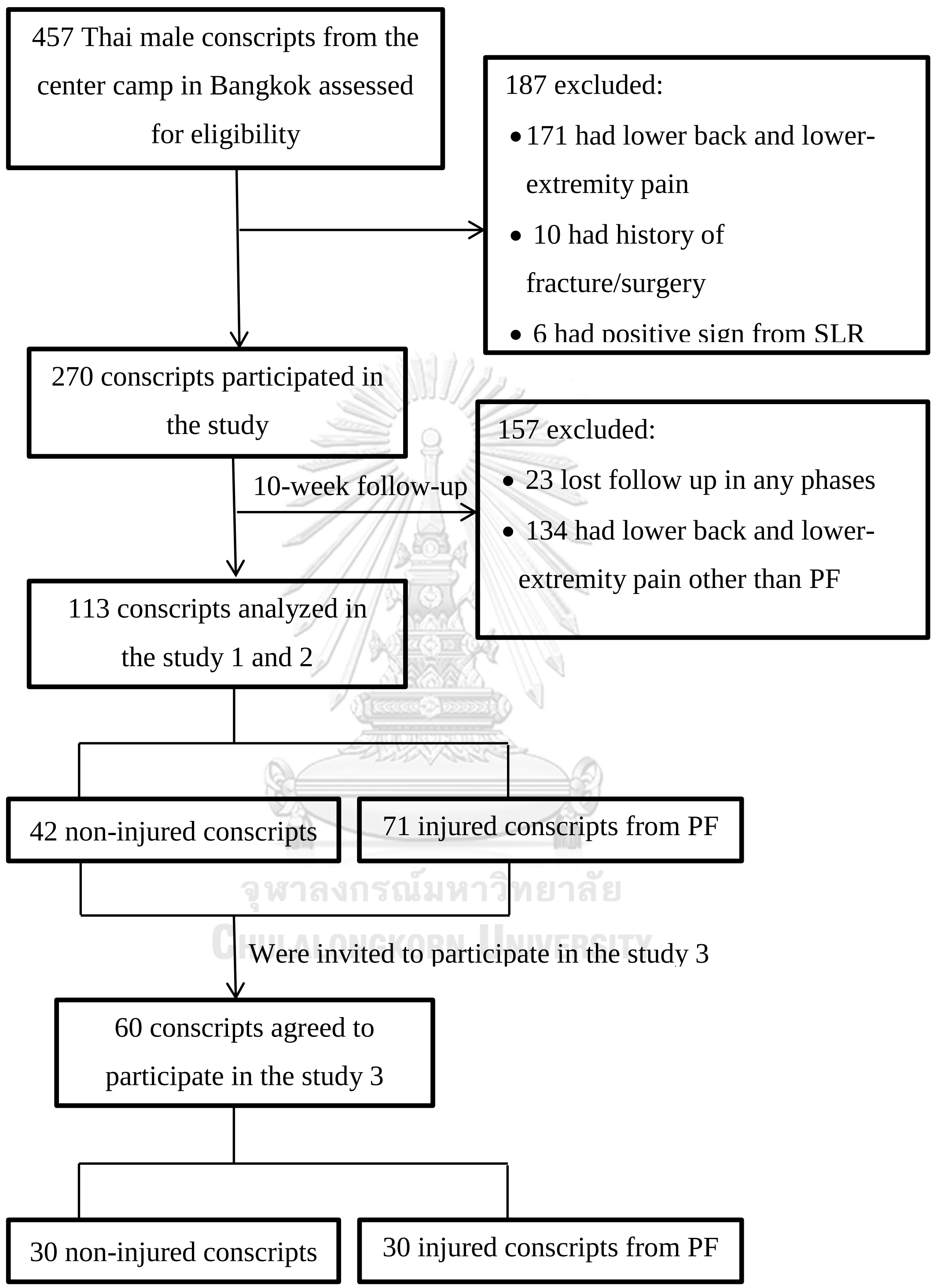
This dissertation was divided into three studies in response to the research questions which are consisted of

Study I Predictors of plantar fasciitis in Thai novice conscripts after 10-week military training: A prospective study

Study II Impacts of physical and psychological variables on pain intensity in conscripts with plantar fasciitis

Study III Differences in lower-extremity kinematics between individuals with and without plantar fasciitis

3.2 Sampling procedure



3.3 Brief method

Three studies were conducted to investigate the anatomical and biomechanical factors related to plantar fasciitis as well as to investigate the differences of lower-extremity kinematics between individuals with and without plantar fasciitis in Thai male conscripts, as shown in Figure 3.1. A prospective cohort study design with a follow-up of 10 weeks was performed in the study 1 and 2; while a cross-sectional study design was performed in the study 3. Brief details in each study were described below.

Study I

Male conscripts were recruited in the present study. A self-reported questionnaire and a set of lower-extremity examination were used to collect data after screening process. With a follow-up period of 10 weeks, both tools were repeated. Dependent variable was the presence and absence of plantar fasciitis. The associated factors in regards to anatomical and biomechanical variables with the presence plantar fasciitis were determined.

Study II

Male conscripts were recruited in the present study. A self-reported questionnaire and a set of lower-extremity examination were used to collect data after screening process. With a follow-up period of 10 weeks, both tools were repeated. Only male conscripts with plantar fasciitis were included for the statistical analysis. Dependent variable was the average pain intensity during last week from plantar fasciitis. The associated factors in regards to anatomical and biomechanical variables with the pain intensity were determined.

Study III

Male conscripts from the study 1 and 2 were recruited in this study. All participants were divided into two groups which consisted of plantar fasciitis group and control group. To collect kinematics data, the assessment of lower extremity which consisted of hip, knee, ankle, rearfoot, midfoot and forefoot motion during the stance phase of gait cycle were performed in the musculoskeletal biomechanics laboratory using a three-dimensional (3D) motion capture system with eight cameras. The kinematic variables of lower extremity between groups during the stance phase were compared.

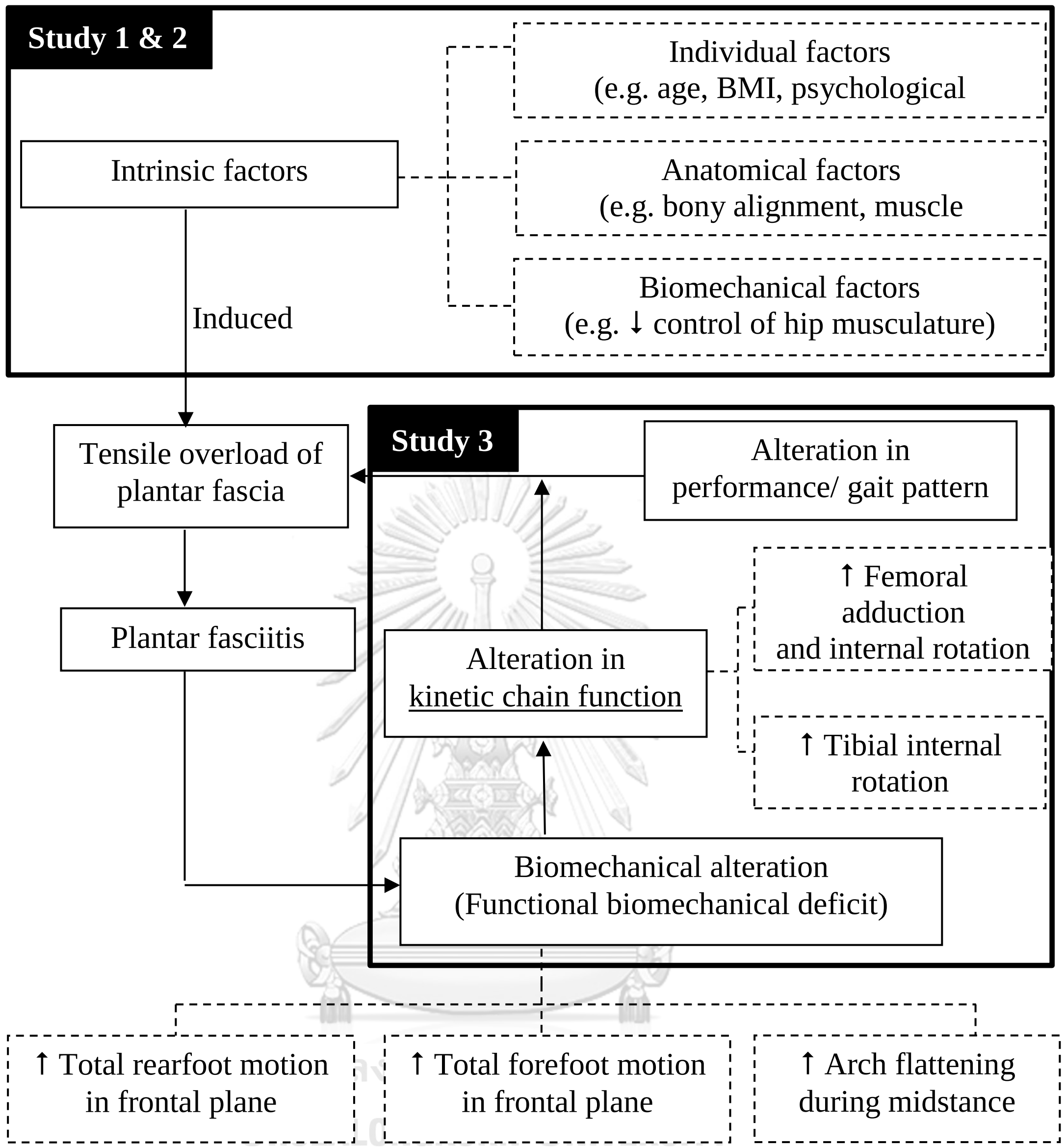


Figure 3.1 Scopes of the present study

CHAPTER 4

STUDY I: PREDICTORS OF PLANTAR FASCIITIS IN THAI NOVICE CONSCRIPTS AFTER 10-WEEK MILITARY TRAINING

4.1 Abstract

Etiology of plantar fasciitis among novice conscripts is multifactorial. The combination of all potential factors should be included for multivariate analysis to determine the significant predictors. The present study aimed to identify the intrinsic predictors (individual, anatomical, and biomechanical predictors) of plantar fasciitis among novice conscripts. Two hundred and seventy healthy male conscripts who were without lower back or lower extremity pain prior to the commencement of military training were participated in this study. Intrinsic variables were assessed in all participants at baseline. After 10 weeks of training, 113 participants were assessed again and classified as having (n = 71) or not having (n = 42) plantar fasciitis. Multiple logistic regression was used to identify significant predictors. The primary criterion variable was the presence or absence of plantar fasciitis. Current results indicated that the conscripts with poorer quality of movement were two times more likely to exhibit plantar fasciitis (OR = 1.996). The conscripts with more femoral anteversion angle decreased the risk of presenting with plantar fasciitis (OR = 0.720). Regarding individual component, the conscripts with higher body mass index and more stress level increased more risk of plantar fasciitis (OR = 1.238 and 1.110, respectively). In addition, the conscripts with higher physical exercises level before military program reduced the risk of presenting with plantar fasciitis (OR = 0.242). In conclusion, multiple factors –

especially individual characteristics and the abnormalities from proximal region (other than foot and ankle) – contributed to the prediction of the development of plantar fasciitis among Thai novice conscripts.

4.2 Introduction

Plantar fasciitis (PF) is a common lower-extremity tendinopathies among conscripts who are otherwise healthy (8, 98). Typical training programs for novice conscripts include running long distances, marching, calisthenic training, crawling, jumping, lifting and carrying loads. Each of these are extrinsic factors that can result in overuse injuries in the lower extremities (99). The requirement that trainees be on their feet for long periods is thought to increase the risk of developing PF (98).

A combination of extrinsic factors, such as vigorous training program and inappropriate footwear, and intrinsic individual, anatomical and biomechanical factors are thought to predispose trainees for developing PF and other lower-extremity overuse injuries (7, 12). Among the intrinsic factors previously shown to predict PF are higher body mass index (BMI), having history of musculoskeletal symptoms at lower extremity, having psychological symptoms (such as depression, anxiety, and stress), limited ankle dorsiflexion, limited first metatarsophalangeal (MTP) joint movement, hamstrings tightness, low ankle plantarflexors strength, having an abnormal foot arch, and excessive foot pronation (3, 14, 16, 52, 100). Such abnormal muscular or structural impairments are thought to change the lower kinetic chain and induce repetitive microtrauma at the proximal attachment of plantar fascia during vigorous activities (3, 17, 101).

The etiology of PF is probably multifactorial (3, 100). Thus, a physical examination specific to only the ankle and foot regions may not provide enough information for the effective prediction and management of PF (12, 102). Clinicians should also perform additional physical examinations of the proximal regions related to the lower kinetic chain. For example, lower-extremity examinations should include the assessment of structural alignment, muscle performance, range of motion and movement patterns (103). Although no previous research has indicated the biomechanical linkage between foot and the whole extremity as playing a role in PF, a recent systematic review on the relationship between hip muscle performance and the injuries in leg, ankle, and foot found that less muscle strength and delayed onset activation were related to leg, ankle and foot injuries (102). Another previous study compared the kinematics and muscle activity of lower extremity between the runners with Achilles tendinopathy and non-injured controls. The study reported that the lower range of knee motion and lower muscle activity of tibialis anterior, rectus femoris, and gluteus medius were significantly found in the injured group (104).

However, there is a lack of high-quality longitudinal studies which have sought to identify the predictors of the development of PF prospectively (100). Although numerous studies using cross-sectional or matched case-control designs have been conducted, such research is not able to identify causal factors. We were only able to identify one prospective cohort study investigating the risk factors of PF in runners. These investigators found that both varus knee alignment and cavus arch posture were significantly associated with a higher risk of the development of PF in their sample among runners (40). However, while these investigators used an appropriate design, the predictors evaluated were limited to just the extrinsic variables and structural alignment of knee and foot. Additional research is needed not only to replicate these findings, but extend them to include additional potential predictors, in order to develop a more comprehensive model of the development of PF.

Given these considerations, the aim of this prospective cohort study was to identify the intrinsic risk factors of PF among Thai novice conscripts. This population is ideal for addressing the study aim because they were under the same extrinsic condition. We hypothesized that various factors especially the abnormalities from proximal region, other than foot and ankle, contributed to the presence of PF during 10-week military training.

4.3 Materials and Methods

4.3.1. Study design

A prospective cohort with 10-week follow up was conducted among Thai male conscripts who attended basic military training from May to July of 2016 at the Infantry Battalion of 11th Military Circle, the center camp of military training in Bangkok, Thailand. Baseline measurement regarding to the various predictors of PF were collected prior to the beginning of military training. After 10 weeks of military training (APPENDIX B), all participants were classified into two groups: (1) a group that developed PF and (2) a group that had not developed PF.

4.3.2. Study population

The study was described to 502 Thai male conscripts who were 20 years old or older and they were invited to participate; 457 of these agreed to participate, signed the informed consent form, and completed a screening questionnaire. Exclusion criteria were (1) having current or history of lower back or lower extremity pain in the last 3 months rated as 3 centimeters or more on a 10-centimeter Visual Analog Scale (VAS), (2) having history of lower-extremity fracture/surgery, or (3) having medical diagnosis of gout, rheumatoid arthritis, systemic lupus erythymatosus (SLE), cancer and infection disease. In addition, individuals with true leg length differences more than 1 centimeter and positive sign from the straight leg raise (SLR) test as indicated by numbness, paresthesia or referred pain at posterior leg were also excluded (105). One hundred and eighty-seven potential participants met at least one of these criteria, and so were excluded from the study. The remaining 270 conscripts were re-assessed after they completed 10 weeks of military training. The study procedures were approved by the Internal Review Board of Chulalongkorn University (approval No. 077/2016).

4.3.3. Questionnaire

A self-administered questionnaire and a set of physical examination will be adopted from literature review. Two different sets of questionnaires were used to assess the study variables. The first set was designed to collect individual factors at baseline, consisting of age, body mass index (BMI), psychological symptoms, and baseline activity. The Depression, Anxiety and Stress Scale short version (DASS-21) was used to assess psychological symptoms including depression, anxiety, and stress (106, 107). Depression scale contains items related to low positive affect, hopelessness, devaluation of life, self- deprecation, and inertia. It does not contain somatic items. High scores on this scale are associated with mood disorders. The anxiety scale has items related to autonomic arousal, physiological hyperarousal, feelings of fear, and panic attacks. High scores on this scale are associated with panic disorder. The stress scale contains items reflecting difficulty relaxing, tension, impatience, irritability and agitation, and overreactivity to stressful events. High scores have been associated with generalized anxiety disorder (106). Baseline activity was assessed using the physical exercises in leisure (PEL) part of the Baecke physical activity questionnaire (108). Both the DASS-21 and PEL have demonstrated validity and reliability in the research setting (106, 108). The second set of questionnaires was administered after 10 weeks of military training. These assessed pain intensity in the lower back, hip/thigh, knee, lower leg, and foot/ankle regions (109) as well as the psychological symptoms (106, 107).

4.3.4. Lower-extremity physical examination

All participants were also given a lower-extremity physical examination at baseline. This examination was adapted from clinical measures assessing anatomical and biomechanical characteristics (32, 103) of the lower extremity, as well as from clinical practice guidelines (2, 3). The goal was to assess physical impairments thought to be related to the development of PF. Each of the assessments used in the present study had been shown to be reliable in the context of lower extremity examination (32, 74, 103). With respect to biomechanical assessment, the lateral step down (LSD) test has been reported as an appropriate tool for determining lower-extremity movement patterns instead of using 3D motion analysis system, the gold standard for biomechanical assessment (32, 110). Prior to collecting data for the current study, we performed a pilot study to compute the intra-rater reliability of all physical examination among 10 male conscripts. The results showed ICC(3,1) ranging from 0.70 to 0.97 and SEM ranging from 0.1 to 3.2 (APPENDIX C).

Pelvic angle was assessed in standing position from anterior (ASIS) and posterior superior iliac spine (PSIS) landmarks. Image J program was then used to measure the angle from digital photograph (Figure 4.1A) (111). Femoral anteversion angle was measured using the Craig test in prone lying with 90° knee flexion of the tested leg (Figure 4.1B) (112). And the tibial torsion angle was determined as the angle between a transmalleolar line and a mid-parallel line to the long axis of femur (Figure 4.1C) (85).

The assessment of knee alignment from photographic analysis included quadriceps angle and knee extension angle. Quadriceps angle at middle patella was determined as the angle between the ASIS and the tibial tuberosity landmarks (Figure 4.1D) (112). To determine the genu recurvatum angle, we measured the knee extension angle at lateral femoral condyle between the greater trochanter and the lateral malleolus landmarks (Figure 4.1E). Participants were classified as having an abnormal angle with the angle more than 10° (113).

Hamstring length was assessed with passive SLR test (Figure 4.1F) (16). Ankle plantarflexors strength was assessed using the single-leg heel rise task (Figure 4.1G). Normal strength was defined as individual repetition at least 25 times and, with each repeat, the range of movement (RoM) was more than 50% of individual full RoM at the 1st time (114). Active ankle dorsiflexion angle was assessed with both knee extension and knee flexion of 90° (Figures 4.1H and 4.1I, respectively) (1). The RoM of the first MTP joint extension was determined as the angle between a line parallel to the bisection of proximal phalange and a line parallel to the bisection of metatarsal bone (Figure 4.1J) (88). Foot alignment was assessed in the standing position. The rearfoot angle was determined as the angle between a line connecting the calcaneal points and the other connecting the leg points (Figure 4.1K) (87).

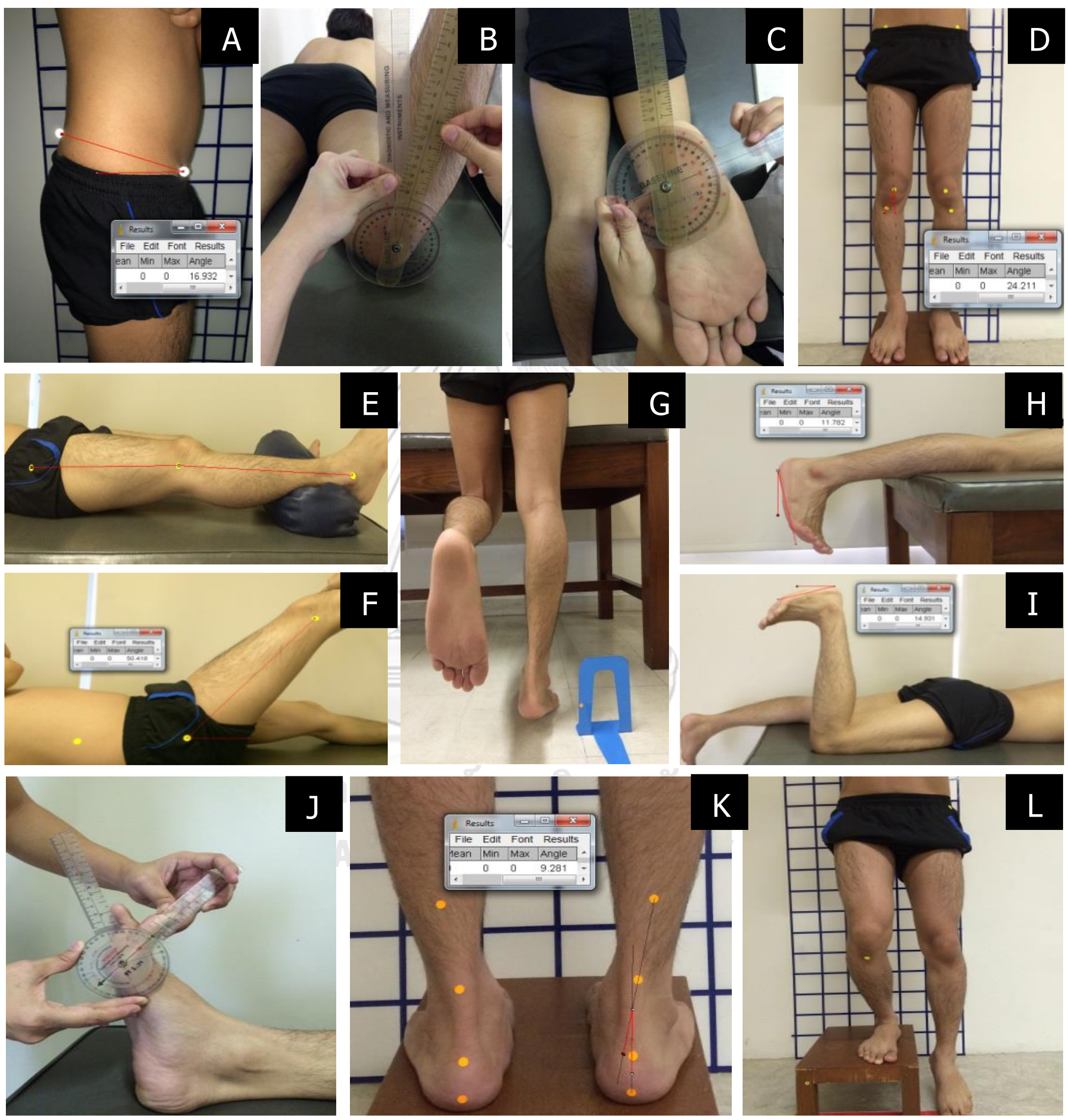


Figure 4.1 Physical assessment in the present study

Lower-extremity movement pattern was measured using LSD test with the contralateral leg hanging down off the 15-centimeter step height (Figure 4.1L). During this task, the examiner rates the participant with respect to five criteria that include arm strategy, trunk alignment, pelvic plane, knee position, and steady stance, as described in table 4.1. The sum score can range from 0 to 6 point, with higher scores indicating poorer quality of movement. Lower-extremity movement pattern is then classified into three quality of movement levels labeled good (0-1 point), moderate (2-3 points), or poor (4-6 points) (32).

Table 4.1 The scoring of lateral step down test (32)

Criterion	Interpretation	Score
Arm strategy	Removal of a hand off the waist	1
Trunk alignment	Leaning in any direction	1
Pelvis plane	Loss of horizontal plane	1
Knee position	Tibial tuberosity medial to second toe	1
	Tibial tuberosity medial to medial border of foot	2
Steady stance	Subject stepped down on nontested limb, or foot wavered from side-to-side	1

4.3.5. Study procedure

A total of 270 participants completed the self-report questionnaires and received the physical examination prior to the beginning of military training from three physical therapists (PTs) who conducted the specific assessments in a standardized manner. At the end of the 10 week military training, a physical therapist (P.H.) with 9 years of clinical experience in the assessment and treatment of foot and ankle problems met with 247 of the participants to diagnose the presence or absence of PF. In addition, the participants were asked to complete the follow-up questionnaire at this time. This questionnaire assessed pain intensity in the lower back, hip/thigh, knee, lower leg, and foot/ankle regions as well as the psychological symptoms. Any participants who endorsed having plantar heel pain for at least 1 week were evaluated for PF using the PF criteria guidelines, which include the presence of tenderness of the medial calcaneal tubercle, heel pain from ordinary weight-bearing activities and heel pain during the first few steps of walking after prolong period of inactivity that gradually decreased after walking for a while (2, 3).

After the follow-up evaluation, the 247 participants were divided into three groups consisting of individuals (1) with a diagnosis of PF (n = 71), (2) without a diagnosis of PF and lower back and lower-extremity pain (n = 42), and (3) without a diagnosis of PF but with lower back and lower extremity pain (n = 134) (see figure 4.2). As this study emphasized the prediction of PF, the participants who endorsed having lower back or lower extremity separately from PF during the military training were excluded from further analysis, leaving 113 participants for the planned analyses.

4.3.6. Statistical analysis

SPSS software version 22.0 was used for quantitative data analysis. We first performed a series of univariate analysis to identify any univariate differences between the participants with and without PF, using either the Independent T test or the Mann-Whitney U test. We then entered any predictors that evidenced significant univariate difference in a multiple logistic regression analysis, using the forward stepwise method. We also calculated adjusted odd ratios (115). The more painful side was selected for the analysis. In case of bilaterally non-injured legs of the healthy group or having equal foot pain intensity of the PF group, the leg side was randomly selected using random numbers generated from a computer program. There were no significant differences of the whole physical examination between both leg sides. All statistical analyses were performed using SPSS software version 22.0 (IBM statistics), with a significance level of P < .05.

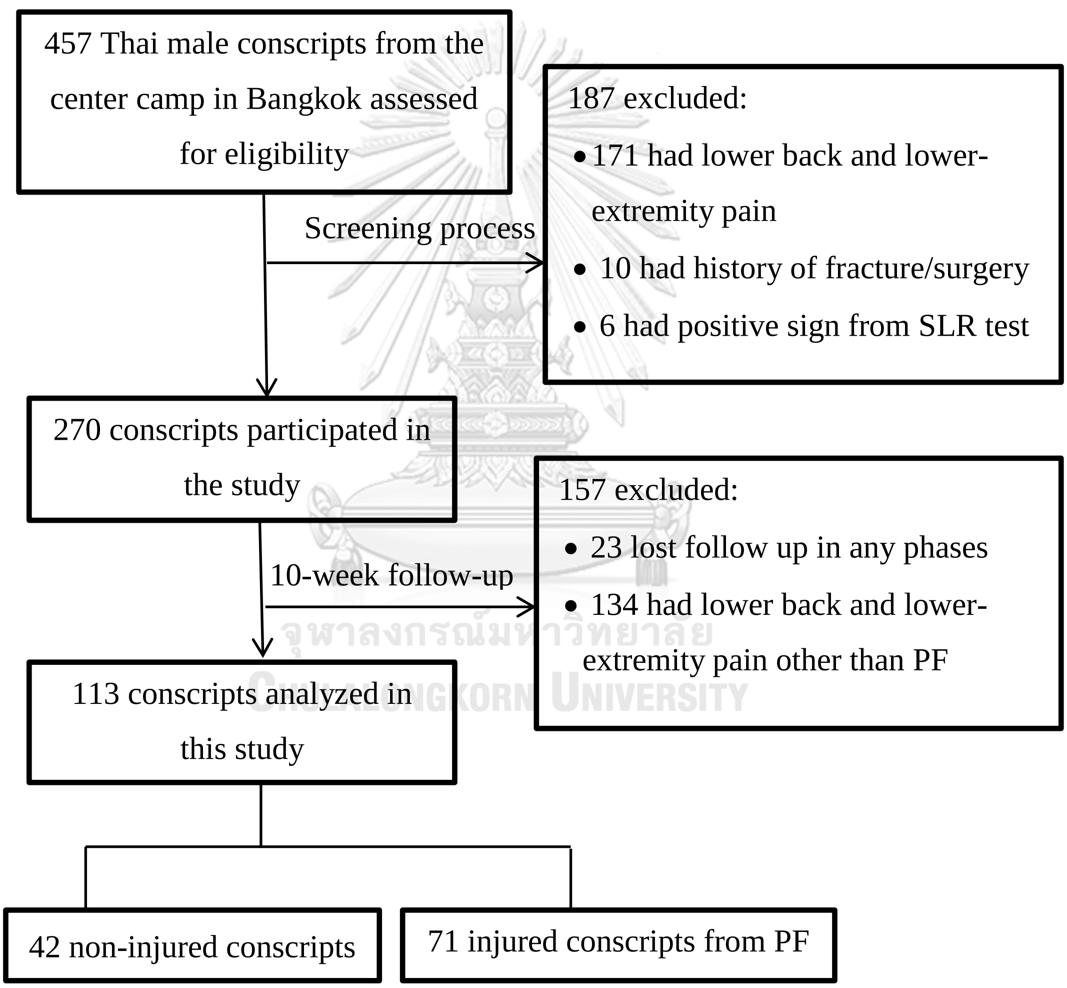


Figure 4.2 A flow diagram of the participations in this study

4.4 Results

Seventy-one (26%) out of 270 conscripts had PF symptoms after 10 weeks of military training. The 71 participants with PF had an average age of 21.54±1.14 years (mean ± standard deviation) and a mean BMI of 23.37±3.81 kg/m^2. The average age of the 42 participants without PF was 21.24±1.03 years, and they had a mean BMI of 20.80±2.69. Sixty participants with PF (85%) reported unilateral foot pain; while 11 (16%) reported bilateral foot pain. As shown in Table 4.2, the PF participants had significantly higher BMI, lower PEL scores, more psychological distress, lower femoral anteversion angle, lower ankle plantarflexors strength, and poorer quality of movement than the participants without PF at baseline (*P*s < .05). At 10 week follow up, the average pain intensity score of the 71 participants with PF was 4.76 ± 2.46 centimeters on the VAS, while the 42 participants without PF had no pain. Regarding the psychological distress, the PF participants also had more depression, anxiety, and stress scores than the participants without PF at the end of military training (*P* = .002, .001, and .001, respectively).

As shown in Table 4.3, the final logistic regression model was statistically significant with a chi-square value of 50.90 (*P* < .001). All of the predictor variables explained 50% (Nagelkerke R^2) of the variance in the incidence of PF and correctly classified 78% of cases. The results indicated that every 1 kg/m^2 increase in the BMI would increase the odds of being in the PF group by 1.238 (95% CI, 1.046-1.466). With respect to the stress score, every 1 point increase in stress score increases the odds by 1.110 (95% CI, 1.020-1.208). Every 1 point increase in the PEL score decreases the odds by 0.242 (95% CI, 0.091-0.642). Individuals with the more 1 degree of femoral anteversion angle decreased the odds by 0.720 (95% CI, 0.567-0.914), while a 1 point higher score for the LSD test increases the odds by 1.969 (95% CI, 1.074-3.608). The strength of ankle plantarflexors was the only significant univariate factor that was excluded from the logistic model.

Table 4.2 Comparison of each predictor between healthy and PF groups

Variables	N (%), Mean (S.D.) Healthy (n = 42)	PF (n = 71)	P-value
Individual factors			
Body mass index	20.80 (2.69)	23.37 (3.81)	< **.001***
Physical exercise index	2.94 (0.61)	2.63 (0.57)	**.005***
Depression scores	7.10 (5.14)	9.92 (6.16)	**.022***
Anxiety scores	7.33 (5.20)	12.20 (7.75)	**.001***
Stress scores	9.95 (4.87)	15.69 (7.45)	< **.001***
Anatomical factors			
Pelvic angle	9.03 (5.24)	8.78 (5.34)	.812
Femoral anteversion angle	11.93 (1.72)	10.25 (2.67)	< **.001***
Tibial torsion angle	20.26 (4.11)	21.84 (5.19)	.096
Quadriceps angle	16.45 (5.88)	16.53 (6.82)	.949
Knee extension angle (genu recurvatum)	3.08 (2.26)	3.65 (2.55)	.311
Hip flexion angle (hamstring length)	54.17 (5.50)	52.49 (8.74)	.213
Ankle plantarflexor strength (heel raising times)	23.31 (4.21)	21.00 (6.51)	**.033***
Ankle DF angle with knee extension	4.64 (4.88)	5.11 (5.33)	.815
Ankle DF angle with knee flexion	19.38 (9.13)	17.66 (7.91)	.293
First MTP joint dorsiflexion angle	79.95 (8.55)	77.49 (8.79)	.149
Rearfoot angle	8.79 (6.35)	8.94 (4.94)	.890
Biomechanical factors			
Quality of movement scores	3.21 (0.78)	3.65 (0.86)	**.005***

* Significance level at *P* < .05

Table 4.3 Multivariate logistic regression analysis of factors associated with an incidence of PF[a] (n=113)

Predictors	**Beta**	**S.E.**	**Adjusted OR (95% CI)**	**P-value**
Body mass index	0.214	0.086	1.238 (1.046 – 1.466)	**.013***
Physical exercise index	-1.418	0.498	0.242 (0.091 – 0.642)	**.004***
Stress score	0.104	0.043	1.110 (1.020 – 1.208)	**.015***
Femoral anteversion angle	-0.329	0.122	0.720 (0.567 – 0.914)	**.007***
Quality of movement scores	0.677	0.309	1.969 (1.074 – 3.608)	**.028***

* Significance level at $P < .05$

[a] Model chi-square test, $\chi 2$ (5) = 50.897 ($P < .001$). Overall percentage of correctly predicted = 77.9%. Goodness of fit (Hosmer and Lemeshow test) = 0.829. Pseudo-R^2= 0.495.

4.5 Discussion

The purpose of this prospective longitudinal study was to identify the multivariate risk factors for developing PF in a sample of young men subject to significant physical exercise and activity (i.e. Thai novice conscripts undergoing 10 weeks of military training). They all were under the same risk of PF, such as high-load activities, training on hard surface, long-distance running and the uses of rigid footwear (8, 10, 51), as shown in APPENDIX B. Of the 113 participants who developed PF or not, the results identify specific intrinsic risk factors for PF among Thai novice conscripts, which include BMI, baseline physical exercise activity, psychological stress, the femoral anteversion angle, and quality of movement from LSD task.

The current findings support a conclusion that multiple factors contribute to the development of PF. While there is some overlap between the predictors of PF in the current study and those from other studies (40, 45), not all of the intrinsic predictors from the current study were the same as those identified in previous two studies. Werner et al. (45) found that intrinsic predictors among the plant workers included job dissatisfaction, forefoot pronation, and high metatarsal pressure. However, the Werner et al. study was not a prospective longitudinal design, so it is not possible to determine these predictors as the cause of PF.

In the only prospective study we could identify, Di Caprio et al.(40) found that the intrinsic risk factors of PF among runners included having a cavus arch and a varus knee. However, in the current sample, the eversion range of both groups fell within normal range (between 3° and 9°) (87) as seen in Table 4.2. These results suggest that most participants in both groups did not have a high arch, low arch or pronated foot. Thus, even if these factors contribute to PF, it would not have been possible to identify them as predictors in the current study due to the lack of variability in these at baseline.

Among all of the anatomical variables, only the femoral anteversion angle was included in the final predictive model. Although the mean angle of both groups were in normal range (between 8° and 15°) (25), the PF group anatomically demonstrated less femoral anteversion than the non-PF group. The magnitude of this difference was higher than the SEM (APPENDIX C). Such difference indicates more lateral rotation of the hip during non-weight bearing; however, these might induced the medial rotation via the subtalar joint articulation during weight acceptance (69). Thus, while walking, the body weight is transferred to the medial side of the foot earlier, which can result in stress on medial foot structures including the plantar fascia, and also reduces the strength of primary foot and ankle muscles for ambulation such as gastrosoleus muscles (24, 25). Although our study did not find the lower strength of ankle plantarflexors to be the significant predictor, individuals with PF reported the lower strength than the healthy participants. Theoretically, the poor strengths of gastrosoleus can lead to an insufficiency to generate their concentric force for gait propulsion. The plantar fascia then increases over tension during windlass mechanism for dynamic arch support (24). The altered timing during this period may disrupt the synchronous movement of the foot, tibia, femur, and pelvic regions which lead to any injuries within the kinetic chain of lower extremity (24, 69).

There is growing evidence for proximal and distal factors as contributing to lower-extremity injury. In this view, each bony segment in the lower limb can be viewed as a rigid link with the connecting joints including the subtalar, ankle, knee and hip joints (69). The current findings indicate poorer quality of movement at baseline in the PF group than in the non-PF group with an acceptable SEM (APPENDIX C). The assessment of movement quality from LSD task included the entire trunk and lower extremity. This suggested the possibility that an alteration of lower-extremity movement pattern, consisting of excessive femoral adduction and medial rotation as well as knee valgus, may have significant implications for distal limb function. Owing to these changes, the overload weight-bearing activity produced excessive medial rotation of femur and tibia as well as more foot pronation, which could lead to the disruption of plantar fascia (21, 61). Despite there being a strong theoretical basis linking between biomechanical dysfunction of the lower limb and foot function, information regarding to the proposed mechanism of PF is needed to further determine the causal chain(s) that can lead to PF. Such analysis could potentially come from research using motion analysis.

Our results also demonstrated a higher risk of PF among the conscripts with higher BMI at baseline. A systematic review also reported BMI as a significant factor concurrently associated with the presence of PF (3). Through the use of a prospective longitudinal design, the current findings provide stronger support for the causal influence of BMI on the development of PF. Individuals who are overweight or obese are two to six times more likely to also have PF, respectively (1). Higher BMI causes additional stress to the plantar fascia especially at its proximal attachment during prolonged weight bearing, which could then induce periosteal lifting and calcaneal spur formation (51).

The present study also identified an association between lower baseline exercise activity level and the development of PF. This finding is in line with previous research investigating overuse injuries in young conscripts (8). It confirms physical activity level as a key predictor of the development of various overuse injuries during military training. Conscripts with lower baseline activity levels have lower tolerance for the physical demands of military training. As a result, they are more susceptible to injury than individuals with higher levels of exercise activity prior to the beginning of military training (8).

Psychosocial factors also appear to play an important role for the development of PF (5, 45). The present study identified the stress as psychological risk factor for the development of PF and also the remaining factor of being PF. As found in the current result, there was significant difference between groups at the end of follow up. Such difference indicated the higher stress score in the persons with PF than those without PF. Previous research in factory workers similarly found job dissatisfaction as social risk factor for the development of PF (45). Another study investigating the impact of depression, anxiety and stress on foot pain scores from the foot health status questionnaire (FHSQ) among the patients with PF found that depression and perceived stress were the significant predictors of foot pain, although anxiety was not associated with foot pain in their model (5). In general, psychological symptoms have been identified as key causes of detrimental impacts on functional status and physical fitness (8). Stress scale from DASS-21 has items related to persistent tension, irritability, and a low threshold for becoming upset or frustrated (negative affect) (106). There are direct interactions between the brain, perceptions and emotional reactions, and the body that influence physical function and symptom expression in each person (116). Every emotional state stimulated a numbers of neurotransmitters from the brain to the body's tissue via the bloodstream. The stress signal that was manufactured from the brain could induce anxiety, depression, and physical pain. Individual mind which contained some physical distress may continue to alarm the fear of movement. The brain, therefore, orders a reduction of blood flow to any specific bones and tissues such as the foot structure and plantar fascia. Such mechanism results in the oxygen deprivation of these specific tissues and susceptibly produce pain symptom (117).

The current study has some limitations which should be considered when interpreting the results. For example, the participants in this study were novice conscripts (i.e., young otherwise healthy men) who underwent a specific course of vigorous physical activity. Thus, the results may or may not generalize to other populations, such as women or older individuals. Replication of the current findings in other populations would be needed in order to determine their generalizability. And the sample size in this study was quite small. According to the rules of thumb for determining sample sizes, at least 186 conscripts were needed to achieve 80% power from the regression analysis (118) (APPENDIX D). However, as seen in Table 4.2, only eight variables were included for the multiple logistic regression; thus, the target sample size should be 114 conscripts.

Despite these weaknesses, the current study also has important strengths. Primary among them is the use of a longitudinal prospective predictive design, which allows for the ability to draw causal conclusions regarding the factors that could contribute to the development of PF. Moreover, to our knowledge, it is the first study to evaluate a broad range (over 17 predictors in all) of potential factors in the same sample. This allowed us to directly compare the relative importance of the predictors. As a result, we were able to identify a number of factors that included both anatomical and psychosocial factors. The findings also highlighted the importance of proximal structures as contributing to the development of PF.

The findings also have important practical clinical implications. For example, they provide an empirically based guide for screening novice conscripts who may be at the greatest risk for developing PF prior to the beginning of military training. Also, as the level of physical exercise and BMI were both found to be associated with greater risk, novice conscripts could be told to both (1) increase their physical fitness and (2) lower their BMI prior to attending the military program. Specifically, a muscle strengthening program of the core trunk and hip could also be included in the military training program to potentially reduce the incidence of PF in this population.

4.6 Conclusion

In conclusion, the results indicated that conscripts with poorer quality of movement were twice as likely to exhibit PF. The conscripts with a lower femoral anteversion angle were at increased risk of presenting with PF. In terms of individual components, the conscripts with a higher body mass index and higher stress level were at increased risk of PF. In addition, the conscripts with a higher physical exercise level before the military program had a reduced risk of presenting with PF. These findings provided epidemiological information regarding the risk factors for PF, which would be useful for preventing overuse injuries of the lower extremities, especially from a military training program. Both prevention and treatment programs should consider the importance of proximal structure and psychological factors in order to achieve a better outcome.

4.7 Acknowledgements

This study was supported by the scholarship from “The 100th Anniversary Chulalongkorn University Fund for Doctoral Scholarship”, Bangkok, Thailand. The authors would like to thank Dr. Mark P. Jensen, the Professor of the Department of Rehabilitation Medicine, University of Washington for his recommendation on the manuscript production; and the Thai male conscripts from the Infantry Battalion of 11th Military Circle, the center camp of military training in Bangkok for their participation in this research.

CHAPTER 5

STUDY II: IMPACTS OF PHYSICAL AND PSYCHOLOGICAL VARIABLES ON PAIN INTENSITY IN CONSCRIPTS WITH PLANTAR FASCIITIS

5.1 Abstract

Ideal strategies to prevent and reduce pain from plantar fasciitis should emphasize both physical and psychological factors. Therefore, identification of the key factors that are highly correlated with pain is important to monitor change in plantar fasciitis management. The objective of this study was to determine the predictors of pain intensity with respect to physical and psychological variables among Thai novice conscripts with plantar fasciitis. A total of 270 Thai novice conscripts without musculoskeletal pain were included. Data were collected on physical variables (i.e. ankle dorsiflexion angle, ankle plantarflexor strength, and quality of lower extremity movement scores) and psychological variables (i.e. depression, anxiety, and stress scores) at baseline. After 10 weeks of military training, 71 Thai novice conscripts developed pain from plantar fasciitis. Data from these participants were analyzed using multiple linear regression with forward stepwise method to determine the significant predictors of pain intensity from plantar fasciitis. The final model from forward regression indicated that the only variables associated with pain intensity from plantar fasciitis were anxiety ($P < .001$) and quality of movement scores ($P = .005$). In conclusion, the conscripts who had higher scores of anxiety and movement quality from the lateral step-down task at baseline developed higher pain intensity from plantar fasciitis after the 10-week

military program. Both prevention and treatment programs should consider the importance of functional core stability and psychological factors in order to achieve a better outcome.

5.2 Introduction

Plantar fasciitis (PF) is the most common cause of patients presenting with plantar heel pain which has an unfavorable impact on health-related quality of life (2). It affects up to 15% of all adult foot complaints and accounts for 8–10% of running or training-related injury. The prevalence of this condition is commonly reported across athletic, occupational, and military settings (2, 3, 10). The training program for male recruits consists of long-distance running of at least 10 km per week and high-load weight-bearing exercises that could increase the risk of PF and other lower extremity injuries (8). Persons with moderate-to-severe heel pain might avoid shifting weight onto the painful foot or walk with an antalgic gait. The nature of pain from PF is not usually disabling; however, it restricts the ability to perform weight-bearing activities in daily life, work, and social and family functions (3).

Although the development of pain from PF is associated with high-load activities, other non-biological mechanisms could affect pain perception (5). Emotional stress of the conscripts in the training program is also the main cause of detrimental impacts on functional status and physical fitness, which lead to susceptibility to overuse injuries (8). Therefore, ideal strategies to prevent and reduce pain should emphasize not only physical factors (e.g. stretching and strengthening exercises of calf muscles (2, 3)), but also psychological factors, in the form of a multidisciplinary intervention. Identification of the key impairments related to pain may assist in depicting physical therapy approaches for patients with PF. If it can be shown that particular impairments induce pain intensity, focusing on such impairments may improve the effectiveness of physical therapy intervention for patients with PF.

Repetitive microtrauma of the plantar fascia induces the loss of fascia elasticity which increases the plantar fascia thickness, especially at the heel region or at its proximal attachment (17). It has been postulated that there is an anatomical connection between the Achilles tendon and plantar fascia; thus, the tensile stress of plantar fascia may increase the tension in the Achilles tendon, which leads to the onset of pain and functional changes in gait (17, 24). Persons with inflexible gastrosoleus muscles produce dynamic midfoot pronation to compensate for a lack of ankle dorsiflexion during the midstance phase. Those with deficit strength have a reduced ability to generate concentric force for gait propulsion. The plantar fascia then increases in tension during the windlass mechanism for dynamic arch support (24). Moreover, any changes in foot biomechanics may disrupt the synchronous movement of the foot, tibia, femur, and pelvic regions, which lead to changes in lower extremity movement (17, 21). A numbers of studies have additionally mentioned the reduction in core trunk and hip muscles as possible risk factors for PF (101, 119). Such impairments could induce greater femoral adduction and femoral medial rotation, possibly followed by tibial medial rotation, which lead to poor shock absorption and result in repetitive injuries of distal parts, including the plantar fascia, during walking (69).

As patients with PF have anatomical and biomechanical alterations of their lower extremities, a number of clinical studies have used stretching and strengthening programs to reduce pain and improve function. However, most of these demonstrated short-term effects (2, 3, 101, 119). A recent meta-analysis study indicated that conservative treatments commonly used for PF management could not provide clinically significant improvements with regard to the minimal clinical important difference (MCID) for the visual analog scale (VAS) of 3 cm (120). Possibly, incomplete recovery or failure to respond to the treatment may be associated with some specific patient characteristics, including physical and psychological factors that would influence the treatment response.

Nowadays, there is limited evidence from prospective cohort studies regarding the prognosis of PF. Since pain is the main complaint of patients with PF, the current study was therefore carried out to examine the predictors of pain intensity in individuals with PF. The objective of this prospective cohort study was to determine whether physical variables (i.e. ankle dorsiflexion angle, ankle plantarflexor strength, and quality of lower extremity movement scores) and psychological variables (i.e. depression, anxiety, and stress scores) were associated with pain intensity in patients with PF. We hypothesized that both physical and psychological factors could influence pain intensity from PF during the military training program.

5.3 Materials and Methods

5.3.1. Study design

A prospective cohort study with a 10-week follow-up was conducted among Thai male conscripts who attended basic military training from May to July 2016 at the Infantry Battalion of the 11th Military Circle, the military training center in

Bangkok city. Baseline measurements were collected prior to the beginning of the military training. After 10 weeks of military training, 71 conscripts were diagnosed as having PF.

5.3.2. Study population

A total of 502 Thai male conscripts aged 20 years and over were invited to enroll in the present study. Of these, 457 conscripts agreed to participate and were subsequently asked to fill out a screening questionnaire. The exclusion criteria consisted of individuals with lower back and/or lower extremity pain during the last three months with a VAS of more than 3 cm, a history of lower extremity fracture/surgery, a medical diagnosis of gout, rheumatoid arthritis, systemic lupus erythematosus (SLE), cancer, and infectious disease. On physical examination, individuals with true leg length difference of more than 1 cm and positive signs from the straight leg raising (SLR) test such as numbness, paresthesia or referred pain in the posterior leg were excluded (105). One hundred and eighty-seven conscripts had at least one of these criteria and were excluded from the study. The remaining 270 conscripts were followed up for a period of 10 weeks during military training. The training program combined daily physical training and military skills training. The daily physical training program comprised running about 40 km per week and physical exercise such as push-ups, sit-ups, pull-ups and chin-ups for about two hours per day. The military skills training included postural training with and without a weapon, periodic road-march training, marksmanship training, maneuvers during the day and at night, throwing explosives, camouflage and reconnaissance training. All participants gave written informed consent before participating and their rights were protected. The study procedures were approved by the ethical committee of Chulalongkorn University (approval no. 077/2016).

5.3.3. Questionnaire

Two different sets of questionnaires were used during the study period. The first set was designed to collect individual and psychological factors at baseline, including age, body mass index (BMI), depression, anxiety, and stress scores. The Depression, Anxiety and Stress Scale short version (DASS-21) was used to evaluate the psychological symptoms; higher scores indicated higher severity of the symptoms (106, 107). Depression scale contains items related to low positive affect, hopelessness, devaluation of life, self- deprecation, and inertia. It does not contain somatic items. High scores on this scale are associated with mood disorders. The anxiety scale has items related to autonomic arousal, physiological hyperarousal, feelings of fear, and panic attacks. High scores on this scale are associated with panic disorder. The stress scale contains items reflecting difficulty relaxing, tension, impatience, irritability and agitation, and overreactivity to stressful events. High scores have been associated with generalized anxiety disorder (106). The second set was a follow-up questionnaire used to screen the conscripts with PF and collect data on average pain intensity from PF in the previous week (2).

5.3.4. Lower-extremity physical examination

Physical variables included ankle dorsiflexion angle, ankle plantarflexor strength, and lower extremity movement pattern. The Lateral Step Down (LSD) test, a clinical biomechanical assessment, was used to determine lower extremity movement patterns (32, 110). Prior to collecting data for the current study, we performed a pilot study to compute the intra-rater reliability of all physical examination among 10 male conscripts. The results showed ICC(3,1) ranging from 0.72 to 0.96 (APPENDIX C), which indicated moderate to good reliability (76).

Active ankle dorsiflexion angle was assessed in a prone position lying with knee extension. The angle was formed between a vertical line and a lateral line of the fifth phalange (Figure 5.1A) (1). In addition, ankle plantarflexor strength was assessed from the single leg heel rise task (Figure 5.1B). The number of sufficient single heel rises was counted and recorded. The task was terminated if the height of the heel rise was less than 50% of the full height measured at the beginning of the task (114).

The lower extremity movement pattern was measured using the LSD test with the contralateral leg hanging down from a 15 cm step height (Figure 5.1C). The participants were instructed to bend the knee of the tested leg until the contralateral leg touched the floor and then return to the starting position. During the LSD task, the examiner rated the scores using five criteria: arm strategy, trunk alignment, pelvic plane, knee position and steady stance. The sum score ranged from 0 to 6 points and a higher score indicated a poorer quality of movement. The abnormalities that could be observed during assessment included: removal of a hand from the waist (1 point), leaning in any direction of the trunk (1 point), movement of the pelvis in the horizontal plane (1 point), medial movement of tibial tuberosity to either the second toe (1 point) or to the medial border of the foot (2 points), and stepping down on the non-tested limb (1 point). Lower extremity movement patterns could be categorized into three levels, consisting of good (0–1 point), moderate (2–3 points) and poor (4–6 points) quality of movement (32).

Figure 5.1 Physical assessment in the present study

5.3.5. Study procedure

Prior to the beginning of military training, a total of 270 participants completed a self-report questionnaire and underwent a physical examination by a physical therapist who was assigned to conduct specific assessments in a standardized manner. At the end of the training, a physical therapist (P.H.) with nine years of clinical experience in the foot and ankle regions met the participants for the diagnosis of PF. All participants were asked to complete the follow-up questionnaire. Those who reported plantar heel pain for at least one week were evaluated for PF following the criteria of PF guidelines, which include tenderness of the medial calcaneal tubercle, heel pain from ordinary weight-bearing activities and immediate heel pain during the first few steps of walking after a prolonged period of inactivity that gradually decreased after walking for a while (2, 3). After the follow-up evaluation, 71 conscripts were diagnosed as having PF (Figure 5.2). Data from this group were used for statistical analysis.

5.3.6. Statistical analysis

Descriptive statistics were used to present the baseline characteristics of the participants and average pain intensity from PF during the previous week. We firstly performed a correlation matrix of the variables to determine the univariate relationships among all variables, by calculating either Pearson or Spearman ρ coefficients. In the case of high correlation (r = 0.65) among all independent variables, only the one that was most correlated with the pain intensity was retained for the multiple linear regression.

To investigate the predictors of pain intensity (in unit cm) among Thai novice conscripts with PF, all independent variables of BMI, depression, anxiety, stress, ankle dorsiflexion angle, ankle plantarflexor strength, and quality of lower extremity movement scores were included for multiple linear regression with the forward stepwise method. Since the significant predictors should be sequentially entered into the regression model (one by one) according to their relationship with the dependent variable, we used the forward selection procedure to analyze data. The significant level of the linear regression was tested at each step and the standardized β coefficients for each variable in the final model were calculated. Regression diagnostics (collinearity and residuals analysis) were performed to check whether the data were appropriate for regression analysis (121). We additionally performed the second model to investigate the predictors of quality of lower extremity movement score, with two independent variables including the ankle dorsiflexion angle and ankle plantarflexor strength. The most painful side was selected for the analysis. In the case of having equal foot pain intensity in the PF group, the leg side was randomly selected from a computer program. However, there were no significant differences in all physical examination tests between both legs. All statistical analyses were performed using SPSS software version 22.0 (IBM statistics), with a significance level of $P < .05$.

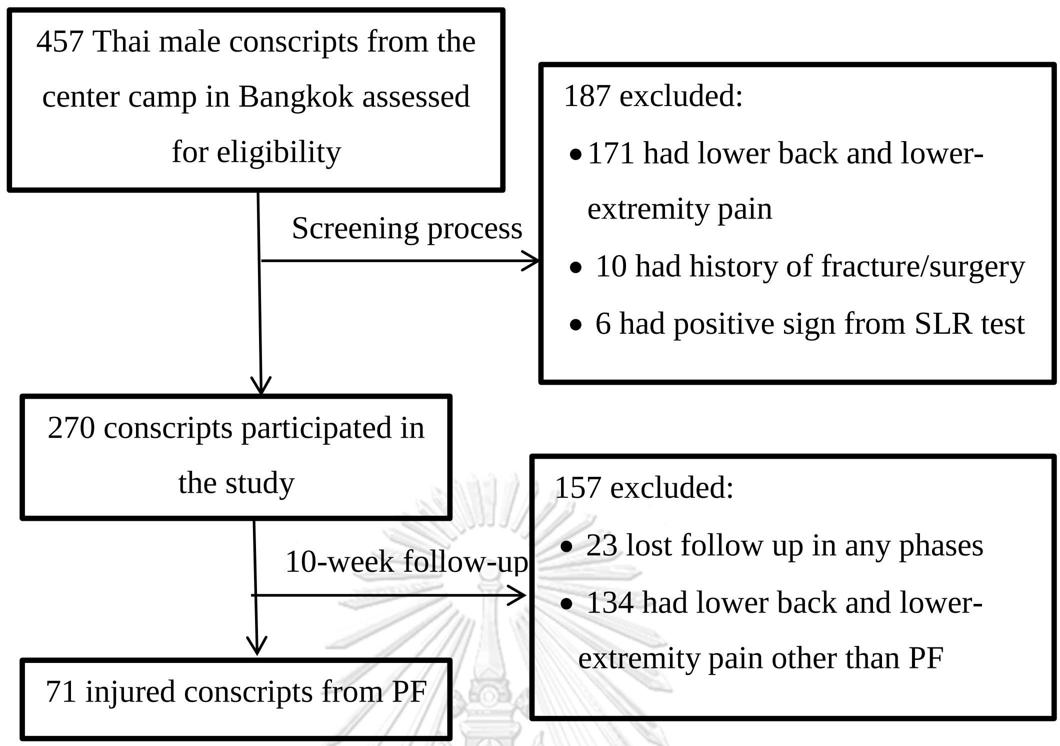


Figure 5.2 A flow diagram of the participations in this study

5.4 Results

Seventy-one (26%) out of 270 conscripts had PF symptoms after 10 weeks of military training. Seventy-one out of 270 conscripts had PF symptoms at the end of the follow-up; an incidence of 26.2%. Among the 71 conscripts with PF, the average age was 21.54 ± 1.14 (mean ± standard deviation) with a mean BMI of 23.37 ± 3.81. Sixty participants with PF (84.5%) reported unilateral foot pain, while 11 (15.5%) reported bilateral foot pain. The average pain score of the 71 participants with PF was 4.76 ± 2.46. Characteristics of the participants are presented in Table 5.1.

Since the anxiety score was highly correlated with the depression and stress scores (Table 5.2), only the variable of anxiety score was included for the multiple linear regression. As shown in Table 5.3, the final model from forward regression indicated that the average pain intensity was associated with anxiety (*P* < .001) and quality of lower extremity movement (*P* = .005). The conscripts with PF who reported higher levels of pain intensity scored higher anxiety and quality of lower extremity movement. From the regression model, there was a 0.129 cm increase in pain intensity for each point of anxiety score; and there was a 0.873 cm increase in pain intensity for each point of quality of lower extremity movement score. The overall model accounted for 25% of the variation in pain intensity. As seen in Table 5.4, the additional regression model indicated that the only variable associated with quality of lower extremity movement was ankle dorsiflexion angle (*P* = .021). The conscripts with PF who reported poorer quality of movement had a lower angle of ankle dorsiflexion. Two models from the regression analysis met the assumptions of homogeneity of variance and linearity; additionally, the residuals were approximately normally distributed.

Table 5.1 Characteristics of the participants (n=71)

Variables	Mean	S.D.
Age	21.54	1.14
Pain level from visual analog scale	4.76	2.46
Body mass index (kg/m^2)	23.37	3.81
Depression scores	9.92	6.16
Anxiety scores	12.20	7.75
Stress scores	15.69	7.45
Ankle dorsiflexion angle	5.11	5.33
Ankle plantarflexor strength (heel raising times)	21.00	6.51
Quality of movement scores	3.65	0.86

Table 5.2 Correlation analysis among the variables

	Correlation coefficient						
	BMI	Depression	Anxiety	Stress	Dorsiflexion	Plantarflexor strength	Quality of movement
Pain intensity	0.072	0.253*	0.378*	0.265*	- 0.113	- 0.101	0.303*
BMI		0.076	0.066	0.145	0.141	- 0.140	- 0.093
Depression			0.648*	0.717*	- 0.180	- 0.261*	0.047
Anxiety				0.733*	- 0.210	- 0.394*	- 0.017
Stress					- 0.296*	- 0.361*	- 0.052
Dorsiflexion						0.224	- 0.201
Plantarflexor strength							0.177

* Significant level at *P* < .05.

Table 5.3 Multiple linear regression to predict pain intensity among Thai novice conscripts with plantar fasciitis†

	B	S.E.	β	T test	P-value
Intercept	- 0.002	1.207			
Anxiety score	0.129	0.033	0.406	3.868	**< .001***
Quality of movement scores	0.873	0.299	0.307	2.917	**.005***

* Significant level at *P* < .01
Abbreviations: *B*, unstandardized coefficient; S.E., standard error of coefficient; β, standardized coefficient
† R square = 0.250

Table 5.4 Multiple linear regression to predict quality of movement scores among Thai novice conscripts with plantar fasciitis†

	B	S.E.	β	T test	P-value
Intercept	3.875	0.138			
Ankle dorsiflexion angle	- 0.044	0.019	- 0.274	- 2.369	**.021***

* Significant level at *P* < .05
Abbreviations: *B*, unstandardized coefficient; S.E., standard error of coefficient; β, standardized coefficient
† R square = 0.075

5.5 Discussion

The main purpose of the current cohort study was to determine the physical and psychological predictors of pain intensity among conscripts with PF. The authors conducted research among this specific population, since they were enrolled in a vigorous training program that could increase injury from PF, with high-load activities, training on hard surfaces, long-distance running, and the uses of rigid footwear (8, 10). This was to ascertain that the level of pain intensity was dependent on physical and psychological variables, not environmental variables. Of the 71 participants with PF studied, the significant variables included the anxiety score and the movement quality from a LSD task. The variables that were found to be highly correlated with pain intensity were important to monitor changes in plantar fasciitis management (122).

Among all physical variables, the current study demonstrated that a higher score from the LSD test—which reflects poorer core stability and quality of lower extremity movement—was associated with higher pain intensity in conscripts with PF. Generally, the components of core stability assessment include strength, endurance, flexibility, motor control, and function (123). The LSD test is the functional assessment of core stability to determine the movement coordination of the arms, trunk, and lower extremities. During this task, the joints of the stance leg are required to flex in order to move the contralateral foot to the floor. Impairment in range of motion or decreased neuromuscular control at any section of the lower extremity may require alternative strategies to complete the task (124). As seen in Table 5.1, the mean angle of ankle dorsiflexion was less than the normative data (angle $< 10°$) (16). Although this factor had little association with the pain intensity, it was significantly associated with poor quality of movement. Individuals with insufficient ankle dorsiflexion might induce excessive knee valgus and trunk leaning to move the contralateral foot to the floor. A compensatory movement to attain more dorsiflexion is pronation of the subtalar joint, which is then related to internal rotation of the tibia and dynamic valgus of the knee (124). It has been assumed that the patients with higher pain intensity from PF had more dynamic pronation of the subtalar joint, which led to elongation and excessive tension of the plantar fascia. In addition, instability of the ankle joint might be associated with the higher pain intensity that led to the poorer quality of movement; however, the present study did not assess the proprioception of the ankle joint and report the history of ankle joint instability.

Although higher BMI and some physical assessments of lower extremity (i.e. lower ankle dorsiflexion angle and lower ankle plantarflexor strength) were reported as risk factors for PF (3, 17), there was little association with the pain intensity. The variables from the current study were different from the variables investigated in previous studies with a multiple regression approach. For example, Riddle et al (122) collected the variables of age, BMI, pain duration, pain intensity, and ankle dorsiflexion angle into the regression model to predict self-reported disability in patients with PF. They found only BMI to be significantly associated with disability. The contrasted findings could reflect not only differences in patient population and condition, including severity and duration of symptoms, but also variable differences in the multiple linear regressions.

With respect to psychological variables, anxiety was the most significant predictor of pain intensity in conscripts with PF. The anxiety scale has items related to autonomic arousal, physiological hyperarousal, feelings of fear, and panic attacks. High scores on this scale are associated with panic disorder (106). This symptom might induce withdrawal and avoidance of functional activities due to negative appraisal of individual capacities. Persons suffering from this condition might reduce their ability to cope with pain. Fear of being hurt and the anticipation of suffering are factors that were found to be highly correlated with the pain intensity (125). However, the current study reported psychological factors differently from previous research. For example, Cotchett et al conducted two studies to determine the impact of psychological factors on foot pain scale in patients with PF (5, 126). One study reported no significant association between each psychological variable i.e. depression, anxiety, stress and foot pain scores from the foot health status questionnaire (FHSQ) in male patients with PF (5). Meanwhile, the other study found significant association between first step pain and pain catastrophizing (126), which is defined as "an exaggerated negative mental state brought to bear during an actual or anticipated painful experience" (127). The latter study also indicated the role of psychological factors in patients with PF. Given the importance of these factors in clinical decision-making, the routine detection of such symptoms might be a further strategy for the effective management of PF.

Some limitations should be noted in the present study. The participants in this study were novice conscripts who represent a population who do vigorous physical activity. The results are not applicable to the general population, such as athletic groups and male groups with the same age range. Therefore, the clinical implication should be recognized before applying to other groups of population and the present results should be validated in other samples of patients with PF. In addition, the sample size in this study was quite small. According to the rule of thumb for determining sample sizes (118) (APPENDIX D), the current study needed 106 conscripts to achieve 80% power from the regression analysis. However, as seen in TABLE 5.2, only five variables were included for the multiple linear regression; thus, the target sample size should be 90 conscripts.

Despite these limitations, the study's major strength was that it was the first prospective cohort study to investigate physical and psychological factors that relate to pain in conscripts with PF. Our study provided information regarding the role of proximal biomechanics, other than only foot and ankle regions, to the development of PF. The significant predictors can be used further to screen novice conscripts who may develop higher pain intensity from PF. Since quality of movement was found to be a predictor of pain from PF, a muscle strengthening program of the core trunk and hip should be additionally included in the military training program prior to the beginning of military training. In addition, further studies should determine the role of psychological factors and how they relate to the pain level from PF.

5.6 Conclusion

The results demonstrate that conscripts who had anxiety and poor quality of lower extremity movement at baseline developed higher pain intensity from PF after the 10-week military program. Focusing on such variables may improve the effectiveness of physical therapy intervention for patients with PF. Both prevention and treatment programs should consider the importance of functional core stability and psychological factors in order to achieve a better outcome.

5.7 Acknowledgements

This study was supported by the scholarship from “The 100th Anniversary Chulalongkorn University Fund for Doctoral Scholarship”, Bangkok, Thailand. The authors would like to thank the Thai male conscripts from the Infantry Battalion of 11th Military Circle, the center camp of military training in Bangkok for their participation in this research.

CHAPTER 6

STUDY III: DIFFERENCES IN LOWER-EXTREMITY KINEMATICS BETWEEN INDIVIDUALS WITH AND WITHOUT PLANTAR FASCIITIS

6.1 Abstract

Tensile stress of plantar fascia from vigorous activities may induce kinematic change of multi-segment foot that could lead to functional changes of lower-extremity kinetic chain during gait. However, this possibility has not yet been adequately examined. This study aimed to evaluate the role that influenced gait by comparing lower-extremity kinematics during the stance phase of the gait cycle between individuals with and without plantar fasciitis. A total of 60 male conscripts participated in the study including 30 conscripts with plantar fasciitis and 30 aged-match controls. Kinematic data of the lower extremity and multi-segment foot regarding the range of motion were analyzed using a three-dimensional motion analysis system. The plantar fasciitis group evidenced significant differences in motion in the multi-segment foot, the ankle, the knee, and the hip from the control group during various subphases of the stance phase. Specifically, and relative to the control group, the plantar fasciitis group had significantly higher rearfoot motion in transverse plane during contact phase. They exhibited lower forefoot motion, knee motion and hip motion in sagittal plane during midstance phase. Moreover, the statistically significant increase in ankle motion in transverse plane and hip motion in frontal plane were detected in the plantar fasciitis group during propulsive phase (all *Ps* < 0.05). In conclusion, individuals with plantar fasciitis evidenced more flexibility in the ankle-foot complex. It seemed that they could not effectively

supinate rearfoot; therefore, it was difficult for persons to naturally transfer body weight from the rearfoot to the medial forefoot during the knee and hip extension. This might lead to the functional change of the lower extremity in the persons with plantar fasciitis when the foot needs more stability to perform appropriate propulsion.

6.2 Introduction

Plantar fasciitis (PF) is an overuse injury commonly related to prolonged weight-bearing activities (100). Military training programs that involve long-distance running, prolonged standing, inverted crawling, hopping, high jumping, and hiking with backpack can increase the risk of lower-extremity injuries, including PF (8, 10). Mechanical overload of plantar fascia from vigorous activities causes microtrauma and subsequent degenerative changes at its proximal attachment, which lead to the loss of fascia elasticity (71, 128). As found in the survey of the present study, risk factors of PF related to anatomical structure and biomechanics were the lower femoral anteversion angle and poorer quality of lower-extremity movement, respectively (129). Such anatomical difference indicates more lateral rotation of the hip during non-weight bearing; however, these might induce the medial rotation via the subtalar joint articulation during weight acceptance (69). Thus, while walking, the body weight is transferred to the medial side of the foot earlier, which can result in stress on medial foot structures including the plantar fascia (24, 25). This suggested the possibility that an alteration of lower-extremity movement pattern, consisting of excessive femoral adduction and medial rotation as well as knee valgus, may have significant implications for distal limb function in the person with PF (129). Owing to these changes, the overload weight-bearing activity produced excessive medial rotation of femur and tibia as well as more foot pronation, which could lead to the disruption of plantar fascia (21, 61). Such functional changes of lower-extremity kinetic chain provide the path of least resistance to motion and the site of compensation for various proximal structures such as lower-extremity muscles, ankle joint, knee joint, and hip joint (24, 130).

Extensive research has been conducted to determine the foot posture and the range of ankle-foot motion related to PF (3, 17, 18, 20, 21, 100). However, much of the previous research of kinematic changes in PF using motion analysis has centered on either single-rigid foot or multi-segment foot models without consideration of hip and knee kinematics (18, 20, 21). With respects to the kinematic study by Chang et al. (21) using the multi-segment foot model, the study compared the rearfoot and forefoot kinematics between PF feet and healthy feet during the stance phase of walking with the constant speed of 1.35 m/s. There were similar movement pattern of the rearfoot and forefoot between groups in all three subphases i.e. contact phase, midstance phase, and push-off phase. This study defined the contact phase as the duration from ipsilateral heel contact to contralateral toe off; the midstance phase as the duration from contralateral toe off to contralateral heel contact; and the push-off phase as the duration from contralateral heel contact to ipsilateral toe off. At heel contact, the rearfoot was inverted and the forefoot was significantly plantarflexed. Then, the rearfoot became everted and the forefoot became dorsiflexed until 80% of the stance phase that reached the maximum movement of the rearfoot and the forefoot during midstance phase. Subsequently, immediately changes into the stability position caused the inverted movement of the rearfoot and dorsiflexed movement of the forefoot during the propulsive phase (21). Although the similar gait pattern was found, the PF feet exhibited more range of rearfoot motion in frontal plane while there was no difference of forefoot kinematics when compared with the healthy feet (21). While, the other two studies using single-rigid foot model found no difference of the rearfoot motion between groups (18, 20). Up to date, the kinematic characteristics of PF in each subphase during stance phase were unclear.

Preliminary research suggests that there are also important biomechanical correlates of PF in aspects of the whole lower extremity during gait. For example, some studies suggest that individuals with PF may shorten their stride length on the affected side to reduce weight-bearing on the painful foot (17, 131). Patients with PF also appear to reduce hip extension during midstance, which results in poor control of the tibia over the foot (25). However, there is limited empirical evidence regarding the role that leg biomechanics – as assessed using motion analysis – plays in PF. Such knowledge has important clinical implications. If research using motion analysis confirms a key role for biomechanics related to the entire leg in PF, then assessment and treatments that target those biomechanics may be important to reduce the risk and severity of PF.

Given these considerations, the main objective of the current study was to identify any differences in lower-extremity kinematics during the stance phase of the gait cycle between individuals with and without PF. Compared with healthy controls (i.e., individuals without PF), we hypothesized that a group of individuals with PF would exhibit (1) more range of motion (RoM) in the frontal and transverse planes of rearfoot and forefoot and (2) less RoM in the sagittal plane of ankle and forefoot in all subphases of the stance and (3) different RoM of hip and knee during the stance phase.

6.3 Materials and Methods

6.3.1. Study design

A nested case-control design within a prospective cohort study had been conducted from July to September of 2016 among Thai male conscripts, who attended 10-week military training from May to July of 2016 at the Infantry Battalion 11th Military Circle, the center camp of military training in Bangkok, Thailand. The study protocol was approved by the Ethics Committee of Chulalongkorn University, Bangkok, Thailand (approval No. 077/2016)

6.3.2. Participants

A total of 60 conscripts agreed to participate in the present study. There were 30 individuals with PF (PF group) and 30 age-matched individuals without any musculoskeletal symptoms of the lower extremity during the military training (control group). They all gave their informed consent prior to the beginning of the study. Participants were included if they were diagnosed as having PF sign and symptom including tenderness of the medial calcaneal tubercle, heel pain after prolonged weight-bearing activities, and heel pain during the first few steps of walking after a prolonged period of inactivity (3); and having numerical pain rating scale (NRS) of less than or equal 3 at heel during gait. Individuals with a positive sign on the straight leg raising test, abnormal foot arch assessed by the arch ratio (132), or leg length discrepancy more than 1 centimeter were excluded. The sample size in this study was calculated based on the study of Chang et al.(21); with that, at least 26 participants per group would have a power of 80% and significant level of 5% to detect the outcome differences between groups (APPENDIX D).

6.3.3. Physical assessment of the lower extremity

Participants' baseline characteristics were assessed prior to the gait assessment. All participants were given a lower-extremity physical examination including the measurements of femoral anteversion angle, tibial torsion angle, ankle dorsiflexion angle, and lower-extremity movement pattern. The intra-rater reliability of all tests in the physical examination showed ICC(3,1) ranging from 0.70 to 0.96 and SEM ranging from 0.1 to 2.9 (APPENDIX C).

Femoral anteversion angle was measured using Craig's test in prone position with 90° knee flexion of the tested leg (Figure 6.1A) (112). Tibial torsion angle was measured to determine tibial rotation in the transverse plane (Figure 6.1B) (85). Ankle dorsiflexion angle was assessed in prone position with two knee positions i.e. full extension (Figure 6.1C) and 90° flexion (Figure 6.1D) (1). Biomechanical assessment from lateral step down (LSD) task was also measured to determine the lower-extremity movement pattern (Figure 6.1E). The lower extremity movement pattern was measured using the LSD test with the contralateral leg hanging down from a 15 cm step height (Figure 5.1C). The participants were instructed to bend the knee of the tested leg until the contralateral leg touched the floor and then return to the starting position. During the LSD task, the examiner rated the scores using five criteria: arm strategy, trunk alignment, pelvic plane, knee position and steady stance. The sum score ranged from 0 to 6 points and a higher score indicated a poorer quality of movement. The abnormalities that could be observed during assessment included: removal of a hand from the waist (1 point), leaning in any direction of the trunk (1 point), movement of the pelvis in the horizontal plane (1 point), medial movement of tibial tuberosity to either the second toe (1 point) or to the medial border of the foot (2 points), and stepping down on the non-tested limb (1 point). Lower extremity movement patterns could be categorized into three levels, consisting of good (0–1 point), moderate (2–3 points) and poor (4–6 points) quality of movement (32). The poorer quality of movement from LSD test reflects the poorer muscular control from Gluteus maximus, Gluteus medius, Biceps femoris, Vastus medialis, Tibialis anterior, and Gastrosoleus during this task (133).

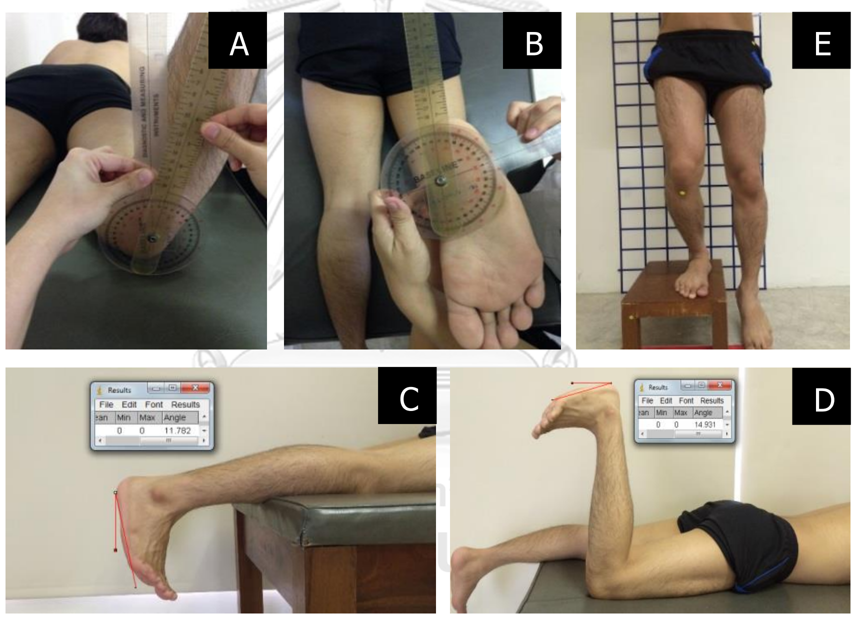


Figure 6.1 Physical assessment in the present study

6.3.4. Gait assessment

Gait assessment was performed at the motion analysis research laboratory of the Faculty of Allied Health Sciences, Chulalongkorn University. This laboratory consists of an eight camera motion analysis system (Motion Analysis Corporation, Santa Rosa, CA, USA) with a sample rate of 120 Hz. The cameras were synchronized with three force transducers (Bertec force plate, Columbus, OH, USA), which were set to have a sample rate of 1200 Hz on a 10-meter walkway. The software for the motion analysis system was Cortex version 2.5 with three major functions consisting of calibration of capture volume, tracking and identifying marker locations in calibrated 3D space, and post-processing tools for tracking, editing, and preparing data for other packages. Marker histories and analog signals were smoothed with a 6^{th} order, low-pass Butterworth filter at 5 Hz and 50 Hz, respectively.

All participants were instrumented with spherical retro-reflective markers using double-sided tape. Markers were placed on anatomical landmarks according to the Helen-Hayes model (134) and the multi-segment foot model (Figure 6.2) (90). Each participant was then asked to walk barefoot on a force plate with a self-selected speed. They performed the walking trials until at least three representative trials were accepted.

Gait parameters were collected from the participants throughout the stance period including walking speed, cadence, stride length, step length, and step width. The stance phase of the gait cycle was defined as the duration between first contact and last contact of the same foot, which was normalized with 100% of the gait cycle. Two peaks of vertical ground reaction forces were used to determine four time periods of the stance phase, which included initial contact phase (ICP), forefoot contact phase (FFCP), foot flat phase (FFP), and forefoot push off phase (FFPOP) (135). With that, ICP was the duration between first foot contact and first metatarsal contact which was similar to the events from ipsilateral heel contact to contralateral heel off (136); FFCP was the duration between first metatarsal contact and forefoot flat which was similar to the event from contralateral heel off to contralateral toe off (136); FFP was the duration between the forefoot being flat and heel off which was similar to the event from contralateral toe off to contralateral heel contact (136); and FFPOP was the duration between heel off and last foot contact which was similar to the event from contralateral heel contact to ipsilateral toe off (136). The combination of FFCP and FFP was grouped into the midstance phase (135).

Figure 6.2 Marker placement based on the Helen-Hayes model and the multi-segment foot model

Kinematic data of the lower extremity during each phase of the gait cycle were computed using custom Mathlab software (R2017a) in all three planes (sagittal, frontal, and transverse). A total of 7 segment models were studied including pelvis, thigh, shank, foot, calcaneus, midtarsus, and metatarsus. Joint angles were calculated using a Cardan XYZ sequence of rotations with six degrees of freedom; and the distal segment was relative to the proximal segment i.e. pelvis-thigh (hip motion), thigh-shank (knee motion), shank-foot (ankle motion), shank-calcaneus or Sha-Cal (rearfoot motion), calcaneus-midtarsus or Cal-Mid (midfoot motion), and midtarsus-metatarsus or Mid-Met (forefoot motion) (90, 134). RoM was defined as the difference between the maximum and minimum joint angles within each subphase of the stance phase (135). The intra-rater reliability testing of lower-extremity and multi-segment foot kinematics showed ICC(3,1) ranging from 0.69 to 0.98 and SEM ranging from 0.01 to 1.85 (APPENDIX C).

6.3.5. Statistical analysis

The comparison of demographic/descriptive variables between participants in the non-PF group (n=30) and the PF group (n=30) was performed using either the independent t-test or the Mann-Whitney U test. RoM of the joints within the lower extremity during the aforementioned gait phases was also compared between groups using either the independent t-test or the Mann-Whitney U test.

In bilaterally symptomatic participants, data from the more symptomatic limb was selected for data analysis; in cases of equal symptoms in both limbs, selection was based on a randomization process. In the control group, the numbers of right and left data sets were randomly matched to the numbers of leg sides from the PF group. There were no significant differences of the kinematic data between both leg sides. Descriptive data were presented with mean (standard deviation). All statistical analysis was performed using SPSS software version 22.0 (IBM Statistics), with a statistical significance level of $P < 0.05$.

6.4 Results

Average age of the study participants was 21.84 (1.46) years with a mean BMI of 21.91 (2.99) kg/m^2. The numbers of right leg and left leg in both groups for this analysis were 20 and 10, respectively. Average NRS during gait in the PF group was 1.26 ± 0.46. As shown in Table 6.1, the PF group had a significantly higher BMI than the non-PF group. Physical assessment of the lower extremity indicated that both groups were significantly different from each other on bony structures; the PF group had less anteversion angle with more tibial torsion angle than the control. There were a higher number of participants with poor quality of movement in the PF group. However, other variables showed no significant differences between groups.

With respect to the gait assessment, there were no significant differences in walking speed, cadence, stride length, step length, and step width between groups, as seen in Table 6.2. Qualitatively, the overall movement patterns of the foot segment, ankle, knee, and hip during the stance phase of the gait cycle were similar between groups (Figure 6.3). During ICP, the ankle was plantarflexed at the beginning and then dorsiflexed at the late of this phase. The movement of rearfoot was similar to the ankle pattern. It was distinctly everted and adducted; the forefoot was dorsiflexed. The knee was also flexed and internally rotated with hip extension. Regarding the midstance (FFCP and FFP), the ankle was dorsiflexed and the rearfoot became inverted and abducted. With this movement of the rearfoot, the knee was externally rotated and extended with hip extension. The forefoot remained dorsiflexed in this phase. During FFPOP, the ankle was plantarflexed, and the rearfoot was more inverted and abducted than the previous phase. The forefoot motion switched to the opposite direction from the previous phase. And the knee became internally rotated and flexed with hip flexion.

RoM of each segment during the four subphases of the stance is presented in Table 6.3. During ICP, the PF group had significantly higher rearfoot motion in the transverse plane and lower forefoot motion in the sagittal plane than the control. However, there was no significant difference between groups of the knee and hip motion. Regarding the FFCP, the PF group showed significantly higher forefoot motion in the frontal plane, whereas lower knee and hip motions in the sagittal plane and lower knee motion in the transverse plane were found. In the FFP, only the forefoot motion in the sagittal plane was different between groups with the lower RoM in the PF group. And during FFPOP, the statistically significant increase in ankle motion in the transverse plane and hip motion in the frontal plane were detected in the PF group.

Table 6.1 Baseline characteristics of the participants in control (n=30) and PF (n=30) groups

	N (%), Mean (S.D.)		P-value
	CTRL	PF	
Body mass index, in kg/m^2	20.4 (2.4)	22.2 (2.9)	.015*,†
Femoral anteversion angle, in degrees	11.9 (1.7)	10.9 (2.6)	.047*
Tibial torsion angle, in degrees	20.4 (4.1)	23.3 (5.0)	.017*,†
Ankle DF angle with knee extension, in degrees	5.6 (5.0)	7.3 (5.6)	.257
Ankle DF angle with knee flexion, in degrees	20.1 (8.7)	20.3 (7.5)	.935
Quality of movement scores, in points	3.2 (0.8)	3.8 (0.8)	.010*,†

* Significant level at p-value < 0.05 † Non-parametric analysis

Table 6.2 Gait parameters of the participants in control (n=30) and PF (n=30) groups

	N (%), Mean (S.D.)		P-value
	CTRL	PF	
Walking speed (m/sec)	1.52 (0.10)	1.55 (0.10)	.268
Cadence (steps/min)	45.56 (5.97)	47.32 (3.78)	.442
Stride length (m)	1.14 (0.08)	1.13 (0.08)	.755
Step length (m)	0.67 (0.08)	0.69 (0.05)	.544
Step width (cm)	12.92 (1.37)	12.99 (1.16)	.988

6.5 Discussion

The primary aim of this study was to compare the lower-extremity kinematics between individuals with and without PF. We controlled the internal validity of this study by recruiting all participants without lower-extremity pain at the beginning of the study and following them up until they developed PF within the period of military training. This was to ascertain that the incidence of PF was due to the military training, not from degenerative processes or chronic conditions. As heel pain from PF could lead to an alteration in gait pattern and kinematic changes of the lower extremity (17, 21), all participants in the PF group were assessed while they had mild heel pain (NRS < 3) during gait. Therefore, the differences of kinematic data between the PF and control groups might be due to the bony structure and quality of movement other than pain. This was confirmed by the results of spatiotemporal data, as the PF group could walk with similar walking speed, cadence, stride length, step length, and step width as did the control group.

Although the gait pattern was similarly observed between groups, the current study demonstrated differently kinematic data from the control group during the stance phase of gait cycle. In ICP, the significant differences between groups were found only in the multi-segment foot; the PF group had higher RoM of rearfoot in transverse plane and lower RoM of forefoot in sagittal plane. In FFCP, the PF group had more RoM of knee in sagittal and transverse planes, hip in sagittal plane, and forefoot in frontal plane. In FFP, only the lower RoM of forefoot in sagittal plane was found in the PF group. In FFPOP, the PF group had higher RoM of ankle in transverse plane and hip in frontal plane. Such differences were higher than the expected variation in observed data due to measurement error or SEM which were ranged between 0.03 and 0.26 (APPENDIX C). Kinematic information during each subphase of the stance is discussed below.

In healthy feet, after the heel contact the floor, the weight is normally transferred to the lateral side of the talus. This creates a valgus thrust on the subtalar joint that resulted in the talus adduction during weight acceptance. The action at this joint precedes and contributes to dorsiflexion of the forefoot and flexion of the knee joint. The tibia and femur were normally internal rotating for shock absorption during this phase (137). According to the present results, an increased transverse plane RoM at rearfoot indicated the more subtalar adduction in the PF group during ICP (Figure 6.3). As adduction is one component of subtalar pronation in the weight-bearing position (136), one might assume that the PF group exhibited more pronation during gait. Increased pronation of the subtalar could facilitate the shifting of the center of pressure from lateral to medial side of the foot, which could inhibit the sagittal movement of the foot and induce early tension of the plantar fascia (138). Another possible cause of increased pronation might be the higher tibial torsion angle presented in the PF group. Greater tibial torsion angle could lead to the excessive movement of the subtalar joint during ICP (139). Once the PF group exhibited more subtalar pronation, they increased the frontal movement of the forefoot during arch flattening as found in the present result. This phenomenon might indicate the elongation of plantar fascia. It was also supported by the fact that the PF group had significantly higher BMI than the control. Previous research suggested that being overweight could add stress on the plantar fascia during gait (51). Subsequently, elongating plantar fascia reduced its elastic properties for storing elastic energy and produced less kinetic energy in the propulsive phase (140).

The mean differences of kinematic data between groups were considered small. Although there was a lack of information regarding the clinically meaningful differences, previous studies and statistics supported meaningful results (21, 141). In accordance with the study of Chang et al. (21), the author compared the multi-segment foot kinematics between individuals with and without PF. They implied that the PF group exhibited a greater magnitude of foot pronation when compared with non PF group. In this study, the mean difference of total rearfoot motion was statistically significant with 1.2° that could represent a 19.3% relative increase of the total motion exhibited by PF individuals (21). Also, a change in the arch angle with approximately 1° could induce plantar fascia tension for almost 50% of its starting tension during the first half of stance (141). These previous studies suggested that small changes of the angle in foot motion might lead to a higher magnitude of fascia strain and other injuries of lower extremity (21, 141).

Since the subtalar joint motion links the foot motions with the motions at lower-extremity joints during the stance phase of the gait cycle (142), any changes in foot biomechanics would alter the vector alignment at ankle, knee, and hip (17). During the FFCP and FFP, the subtalar normally became supinated that could induce the midtarsal axes to become non-parallel alignment, resulting in the more rigid of the foot than the previous phase to support the body weight (142). As the axis of rotation of the ankle joint locates in superior and anterior directions, the supinated subtalar normally promotes this axis to externally rotate the lower extremity during knee and hip extension (136). The current result from the physical assessment of lower-extremity structure demonstrated that the PF group had more external tibial torsion than the control. This difference of the bony alignment, which facilitated the medial malleolus to shift forward and lateral malleolus to shift backward, might propose that there was a change of axis of rotation. It seemed that PF individuals could not effectively supinate the subtalar joint, since they exhibited less external rotation of the tibia. Consequently, it was difficult for persons to naturally transfer body weight from the rearfoot to the medial forefoot during the knee and hip extension (139).

Moreover, the PF group had poorer quality of movement. It was thus assumed that they had less activation from the hip and knee extensors to stabilize the trunk and limb against the rapid transfer of body weight (133). Since the femoral anteversion angle and tibial torsion angle of the current sample fell within normal range (between 8° and 15° for femoral anteversion; and between 20° and

40° for tibial torsion), any changes in multi-segment foot and lower extremity kinematics during this phase might be due to the poor muscular control from trunk and hip other than the anatomical structures. These might reduce external rotation of the tibia and supination of the subtalar joint. The tensile stress of plantar fascia was thus increased due to the reduction of foot stability, which might lead to the lower RoM of forefoot, knee, and hip in sagittal plane as well as knee in transverse plane relative to the non PF group.

Normally during FFPOP, extension of the 1st metatarsophalangeal joint pulls the plantar fascia into downward movement. The plantarflexed position of the ankle and the rays raise the medial longitudinal arch and supinate the subtalar joint to enhance arch stability; the hip and knee were thus flexing and externally rotating to propel the body forward (136). According to the present result, the PF group exhibited more adduction of the ankle and more abduction of the hip (Figure 6.3). Such kinematic differences might be explained by the poorer quality of movement in this group. Generally, quality of movement is accepted as the function of neuromuscular control or movement coordination, not just muscular action (143). As the PF group had poorer quality of movement, there might be more drop of the pelvis of the pushing leg. When considering the pelvic movement relative to the femur, dropping of the pelvis involves ipsilateral hip abduction. It was assumed that the PF group had less activation from the Gluteal muscles to stabilize the trunk and Gastrosoleus muscles to push the limb forward. Excessive activity might be required from extrinsic and intrinsic muscles of the foot to reinforce the medial arch, leading to more tension on the plantar fascia (144).

A number of study limitations should be considered when interpreting the results. For example, the sample was from a population of healthy young men who participated in 10 weeks of military training. The extent to which these findings generalize to other populations of individuals with and without PF is not known. Additional research with other populations would be needed in order to determine their generalizability. Moreover, the present study investigated only kinematic data; we did not assess kinetic data or muscle activity during gait assessment. Longitudinal and experimental research would be needed to gain more information and to establish causal relationships between these biomechanical assessments and the presence of PF.

Despite the study's limitations, the findings provide important new information on the kinematic factors that distinguish individuals with PF from those without PF. To our knowledge, this is the first study to investigate kinematic data of knee and hip motion in individuals with PF. The role of the proximal segment in the development of PF was investigated in the current study. Further studies should provide more information regarding the role that these factors may play as mechanisms of PF and as factors that differentiate individuals with and without PF in general population.

Table 6.3 Summary of mean range of motion and standard deviation (in degrees) during four subphases of stance for control and PF groups

		Initial contact			Forefoot contact			Foot flat			Forefoot push off		
		CTRL	PF	*P*	CTRL	PF	*P*	CTRL	PF	*P*	CTRL	PF	*P*
Rearfoot													
	Sagittal	9.2 (1.4)	9.0 (1.4)	.491	5.1 (2.6)	5.4 (1.6)	.282	4.6 (2.0)	5.3 (1.9)	.216	23.3 (2.5)	23.0 (3.1)	.728
	Frontal	5.3 (1.5)	5.0 (1.5)	.414	2.5 (1.1)	2.6 (1.2)	.726	4.2 (1.5)	4.5 (1.7)	.477	5.3 (2.0)	5.9 (2.0)	.247
	Transverse	5.4 (1.7)	6.4 (1.9)	**.034***	4.5 (1.7)	4.0 (1.5)	.166	3.5 (1.8)	3.9 (1.4)	.340	5.6 (2.1)	5.8 (2.3)	.770
Midfoot													
	Sagittal	7.4 (3.3)	7.0 (3.4)	.587	2.2 (1.1)	2.6 (1.7)	.536	3.7 (1.6)	3.9 (1.6)	.788	7.2 (2.5)	6.7 (1.8)	.319
	Frontal	4.8 (2.0)	4.0 (1.6)	.084	1.7 (0.8)	1.7 (0.8)	.972	2.5 (1.2)	2.6 (0.9)	.484	3.9 (1.5)	3.9 (1.1)	.992
	Transverse	4.0 (1.6)	4.0 (1.8)	.885	1.7 (1.1)	1.5 (1.1)	.307	2.5 (0.8)	2.6 (1.4)	.706	4.0 (1.9)	3.8 (1.9)	.767
Forefoot													
	Sagittal	8.0 (2.4)	6.3 (2.0)	**.007***,†	3.5 (1.8)	3.6 (2.2)	.657	5.9 (1.8)	5.0 (1.6)	**.037***	11.9 (2.7)	10.8 (2.4)	.075
	Frontal	5.4 (2.7)	5.3 (2.4)	.882	1.4 (0.6)	2.0 (1.4)	**.040***,†	3.6 (1.4)	3.5 (1.4)	.667	6.3 (2.1)	6.1 (2.3)	.774
	Transverse	4.7 (1.6)	4.7 (1.4)	.935	1.9 (1.0)	1.9 (1.0)	.968	4.1 (1.0)	4.2 (1.5)	.960	8.8 (2.4)	8.5 (2.6)	.579
Ankle													
	Sagittal	9.6 (2.3)	9.1 (1.2)	.619	5.3 (2.0)	5.6 (1.5)	.604	4.5 (2.4)	5.2 (2.2)	.236	26.3 (3.6)	26.7 (4.1)	.699
	Frontal	8.7 (2.6)	8.2 (2.6)	.427	2.2 (1.2)	2.1 (1.4)	.443	5.7 (1.6)	5.7 (2.0)	.985	8.8 (3.2)	8.8 (3.6)	.798
	Transverse	7.4 (2.8)	7.7 (2.5)	.731	4.9 (1.9)	4.6 (1.7)	.382	4.1 (1.7)	4.9 (2.0)	.078	4.8 (1.6)	6.1 (2.7)	**.017***
Knee													
	Sagittal	11.8 (4.8)	11.0 (4.2)	.491	8.1 (3.8)	6.2 (2.7)	**.036***	5.4 (2.0)	4.9 (1.7)	.307	36.0 (3.5)	35.9 (4.1)	.713
	Frontal	4.5 (1.7)	4.1 (1.5)	.359	1.7 (0.8)	1.5 (0.6)	.428	2.0 (0.7)	1.8 (0.4)	.054	3.6 (1.9)	4.1 (1.5)	.085
	Transverse	4.8 (1.6)	4.5 (1.8)	.319	2.9 (1.3)	2.2 (0.8)	**.009***	2.4 (1.0)	2.0 (0.8)	.098	9.2 (2.6)	8.6 (4.0)	.231
Hip													
	Sagittal	6.8 (2.5)	7.9 (2.8)	.116	14.4 (3.8)	12.6(2.8)	**.037***	13.9 (2.9)	14.1 (3.6)	.787	8.5 (1.9)	8.5 (2.0)	.994
	Frontal	7.4 (2.0)	6.9 (1.6)	.358	2.7 (1.3)	2.4 (1.1)	.451	1.7 (0.8)	2.1 (1.3)	.264	10.1 (2.8)	11.5 (2.3)	**.033***
	Transverse	7.3 (3.1)	7.0 (3.3)	.468	3.2 (1.2)	3.1 (1.5)	.768	2.9 (1.4)	2.9 (1.2)	.726	6.4 (3.5)	7.0 (3.4)	.468

* Significant level at p-value < 0.05   † Non-parametric analysis

Figure 6.3 Joint angle in each segment during the stance phase of the gait cycle

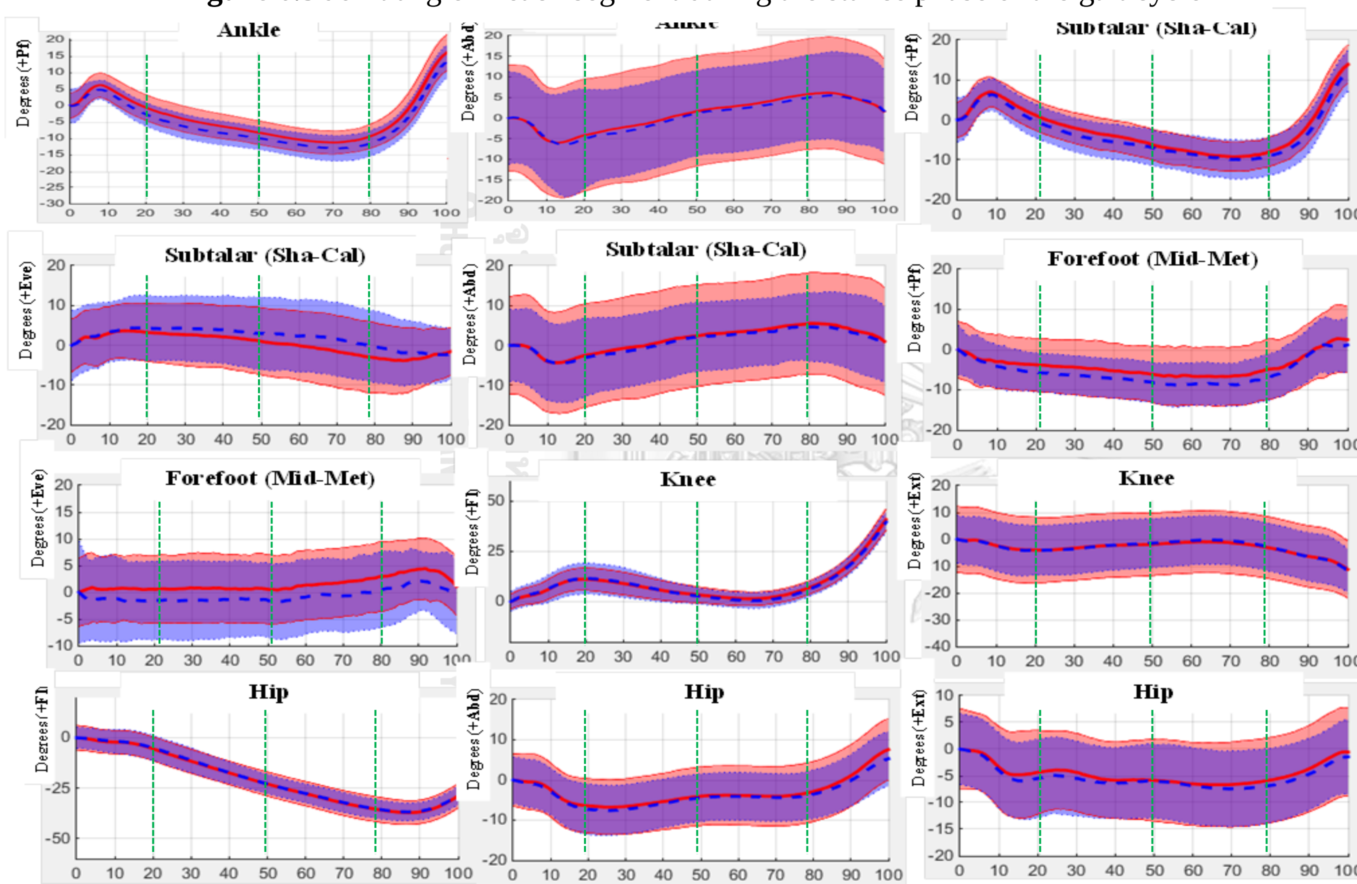


Illustration of the synchronized motion occurring in individuals with plantar fasciitis (red straight line) and the control (blue dashed line). The purple shade and red shade represents standard deviation of the plantar fasciitis group and the control group, respectively. The green dotted line separated the total stance into four subphases i.e. ICP, FFCP, FFP, FFPOP. Pf/Df = Plantarflexion/Dorsiflexion, Abd/Add = Abduction/Adduction, Eve/Inv = Eversion/Inversion, Fl/Ex = Flexion/Extension, Ext/Int = External rotation/Internal rotation.

6.6 Conclusion

With normal foot arch, the significant observation between groups clarified some differences of lower-extremity kinematics. The PF group had different kinematic data of the whole lower extremity and multi-segment foot from the control group in all four subphases. In ICP, the PF group had more transverse plane RoM at subtalar and less sagittal plane RoM at forefoot. In FFCP, the PF group had more frontal plane RoM at forefoot, whereas less sagittal plane RoM at knee, transverse plane RoM at knee, and sagittal plane RoM at hip. In FFP, the PF group had less sagittal plane RoM at forefoot. In FFPOP, the PF group had more transverse plane RoM at ankle and frontal plane RoM at hip. The study provides clear evidence that individuals with PF had more flexibility of the ankle-foot complex and poor overall quality of movement. Apart from the distal segment, the proximal involvement possibly affected the presence of PF. Consideration of the intervention for the conscripts with PF should include the biomechanical adaptation of hip, knee, and ankle other than only multi-segment foot. These notions need further investigation, including in additional populations.

6.7 Acknowledgements

This study was supported by the scholarship from "The 100th Anniversary Chulalongkorn University Fund for Doctoral Scholarship", Bangkok, Thailand. The authors would like to thank Dr. Mark P. Jensen, the Professor of the Department of Rehabilitation Medicine, University of Washington for his recommendation on the manuscript production and Mr. Vasapol Teravanapanth for Mathlab analysis.

CHAPTER 7

GENERAL DISCUSSION AND CONCLUSION

Current study identify a number of interesting factors that related with PF such as psychological issue, the role of proximal structure, not from foot and ankle, and biomechanical assessment of lower extremity. As the present findings highlighted the importance of proximal contribution to the development of PF, consideration of the intervention for PF should include the biomechanical perspectives of hip, knee, and ankle other than only foot.

7.1 General discussion

Regarding general walking biomechanics during the stance phase, the hip and knee extensor muscles are activated to stabilize the trunk and limb against the rapid transfer of body weight during the initial contact and forefoot contact phases. There is also an increase in the hamstrings and single joint hip extensors to enhance knee stability. The control from ankle dorsiflexors provides a heel rocker for progression and knee flexion for shock absorption. During the single-limb support or midstance phase, the trunk stability depends almost entirely on ankle plantarflexors especially soleus and gastrocnemius. Knee and hip extensor stability is provided passively by body alignment. Activation of the hip abductors that actually began in the previous phase enhances lateral stability of the pelvis and trunk on the stance limb. Subtalar and midfoot stability is gained from the peri-malleolar muscles. During the propulsive phase, the limb is unloaded by the rapid transfer of body weight onto the other limb. The knee and hip are unlocked from their extended positions, and flexion is initiated. Dynamic dorsiflexion provides the necessary foot control (137). The Gastrosoleus muscles are most active to generate force for toeing off. In addition, other ankle plantarflexors especially tibialis posterior also acts to provide the rigidity of the foot by locking the midtarsal joint (24).

Considering the function of plantar fascia during gait, it prevents excessive medial longitudinal arch elongation together with eccentric contraction of toe flexors muscles during the midstance phase. An increased tension of plantar fascia provides the arch stability and assists re-supination of the foot during the late midstance and propulsive phases (24). The foot functions as rigid lever arm via windlass mechanism or arch-raising mechanism. Extension of the 1st metatarsophalangeal joint pulls the plantar fascia which wraps the plantar side of metatarsal head into downward movement. The plantarflexed position of the rays raises the medial longitudinal arch and increases stability of midtarsal joint (36). Thus, the plantar fascia plays an important role in supporting the arch under different loading condition and assisting in toe off (36).

As found in the current results, the overall movement patterns of the foot segment, ankle, knee, and hip during the stance phase of the gait cycle were similar between groups. However, the PF group had different kinematic data of the whole lower extremity and multi-segment foot from the control group in all four subphases. Such kinematic differences might be due to the anatomical and biomechanical differences between groups. The results indicated that the PF group had lower femoral anteversion angle and higher tibial torsion angle than the control.

Such anatomical differences may induce more dynamic pronation of the foot in the PF group during the contact phase. Increased foot pronation could facilitate the shifting of the center of pressure from lateral to medial side of the foot, which could induce early tension of the plantar fascia from its elongation (138).

Regarding the biomechanical perspective, individuals with PF had poorer quality of movement from the lateral step down test, reflecting the poorer muscular control from Gluteus maximus, Gluteus medius, Biceps femoris, Vastus medialis, Tibialis anterior, and Gastrosoleus during this task (133). Although the present study did not assess the muscle activity during gait, it was assumed that there were differences of muscle activation between the PF and the control groups. The PF group might reduce activation from the hip and knee extensors to stabilize the trunk and limb against the rapid transfer of body weight (133). With poorer hip control in the PF group, excessive activity might be required from extrinsic and intrinsic muscles of the foot to reinforce the medial arch especially during the windlass mechanism, leading to more tension on the plantar fascia (144). This might explain the reason why the PF group exhibited more adducted movement of the ankle to propel the body forward as reported in the present result.

To clearly understand the pathomechanics of PF, this study provide a new framework in Figure 7.1. A number of intrinsic factors pronounced the tensile overload of plantar fascia which led to repetitive microtrauma at proximal attachment of plantar fascia or the presence of PF. Any changes of plantar fascia properties after the injury might induce the changes of multi-segment foot and lower-extremity during the stance phase of gait cycle. Consequently, there was alteration in the gait pattern that might induce the tensile overload of plantar fascia as the cycle of overuse injury.

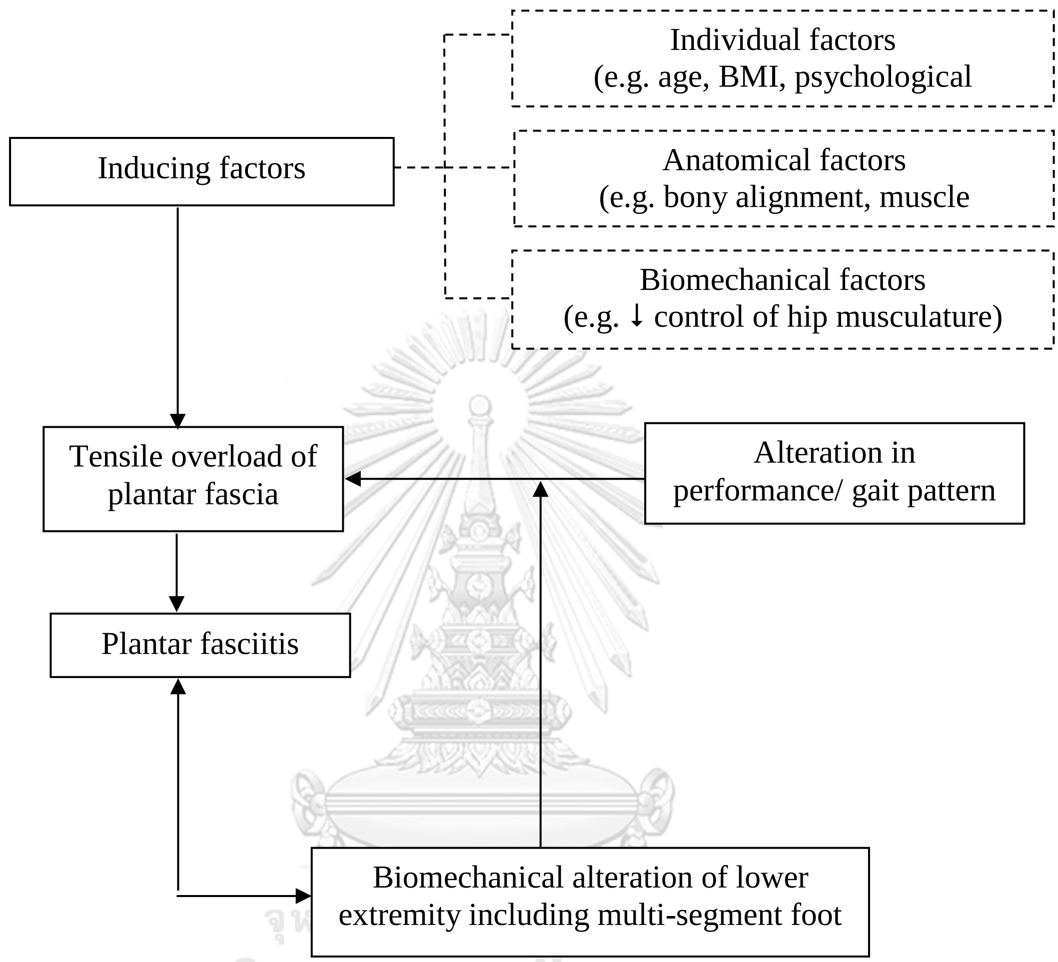


Figure 7.1 A new conceptual framework

7.2 Strength and Limitation

The current study has important strengths. Primary among them is the use of a longitudinal prospective predictive design, which allows for the ability to draw causal conclusions regarding the factors that could contribute to the development of PF. Moreover, to our knowledge, it is the first study to evaluate a broad range (over

17 predictors in all) of potential factors in the same sample. This allowed us to directly compare the relative importance of the predictors. The findings also provide important new information on the kinematic factors that distinguish individuals with PF from those without PF. To our knowledge, this is the first study to investigate kinematic data of knee and hip motion in individuals with PF. The role of the proximal segment in the development of PF was investigated in the current study.

Despite these strengths, a number of study limitations should be considered when interpreting the results. Firstly, the sample was from a population of healthy young men who participated in 10 weeks of military training. The extent to which these findings generalize to other populations of individuals with and without PF is not known. Secondly, the present study investigated only kinematic data; we did not assess kinetic data or muscle activity during gait assessment. Other than the lower-extremity biomechanics, the trunk and pelvis should be additionally investigated. Also, the biomechanical assessment should include data from the swing phase especially during the late swing phase to determine the joint position and muscle activity before the initial contact; such data may be used to clearly explain the pathomechanics of PF. Longitudinal and experimental research would be needed to gain more information and to establish causal relationships between these biomechanical assessments and the presence of PF. Thirdly, the physical assessment of the lower extremity should include the assessment of hip range of motion in all directions and the muscle strength of hip adductors, hip extensors, knee extensors. Moreover, the assessment of lumbar spine curvature and its movement should be included for this analysis to clearly determine the biomechanical linkage of trunk and lower extremity in the persons with PF. Consequently, the more participants at baseline should be included to determine the comprehensive predictors of PF. Lastly, the follow-up period was quite short to clarify the risk of PF and detect any changes of tissue properties from the injuries. Further studies to determine the risks among general population should concern the appropriate times of following up.

7.3 Implication for current practice: Bridge among study I, II, III

Differences of lower-extremity kinematics may be due to the poor quality of movement, reflecting poor trunk and hip control. To prevent the injury from PF, the conscripts should be assessed for mental health status, BMI, physical activity level, lower-extremity alignment and quality of movement prior to the beginning of military training. Both prevention and treatment programs should consider the importance of functional core stability in order to achieve a better outcome. In addition, psychological consulting for mental health should be provided to reduce the risk of PF during the military training.

7.4 Recommendation for further studies

The assessment of muscle activity during walking should be added to clearly understand the kinematic differences in each subphase. Kinematic and kinetic values in swing phase should be additionally evaluated to increase the understanding of gait pattern. Further studies should determine the joint stabilization and movement pattern of trunk and pelvis during walking. In addition, the role of other dimensions of psychological factors, such as coping strategy or fear avoidance belief and how they relate to pain from plantar fasciitis should be additionally evaluated. Replication of the current findings in other populations would be needed in order to determine their generalizability.

7.5 Conclusion

The results indicated that conscripts with poorer quality of movement were twice as likely to exhibit PF. The conscripts with a lower femoral anteversion angle were at increased risk of presenting with PF. In terms of individual components, the conscripts with a higher body mass index and higher stress level were at increased risk of PF. In addition, the conscripts with a higher physical exercise level before the military program had a reduced risk of presenting with PF. With respect to the predictors of average pain intensity during last week in the conscripts with PF, the results demonstrate that conscripts who had anxiety and poor quality of lower extremity movement at baseline developed higher pain intensity from PF after the 10-week military program.

The PF group had different kinematic data of the whole lower extremity and multi-segment foot from the control group in all four subphases. In initial contact phase, the PF group had more transverse plane RoM at subtalar and less sagittal plane RoM at forefoot. In forefoot contact phase, the PF group had more frontal plane RoM at forefoot, whereas less sagittal plane RoM at knee, transverse plane RoM at knee, and sagittal plane RoM at hip. In foot flat phase, the PF group had less sagittal plane RoM at forefoot. In forefoot push off phase, the PF group had more transverse plane RoM at ankle and frontal plane RoM at hip. The study provides clear evidence that individuals with PF had more flexibility of the ankle-foot complex and poor overall quality of movement. Apart from the distal segment, the proximal involvement possibly affected the presence of PF.

APPENDIX

APPENDIX A

THE PREVALENCE OF PLANTAR FASCIITIS AMONG MALE CONSCRIPTS UNDER ROYAL THAI ARMY IN BANGKOK

A cross-sectional survey study was conducted to describe the presence of plantar fasciitis during military training among the male conscripts under Royal Thai Army in Bangkok. Data collection was done in August 2015. Five hundred questionnaires were sent into the military training units. A total of 339 participants sent the questionnaire back. All of them were male conscripts with the average age of 21.8 ± 1.2 (means ± standard deviation) and average BMI of 22.0 ± 2.9 which were classified into normal group (the cut-off value for overweight group = 25.0 kg/m^2) (WHO, 2004). One hundred and thirty four participants (39.5%) reported their heel pain during the training period. Eighty participants (23.6%) reached the criteria of plantar fasciitis. For the open-ended question, the subjects reported their pain at foot region with the highest rate of 20.4%, then at lower leg region of 16.5%, upper leg region of 14.5%, ankle region of 12.7%, and knee region of 9.4% respectively. All data were presented in the table below.

Table Characteristics of male conscripts (n=339)

Characteristics	**N**	**%**	**Mean**	**SD**
Age (Years) (min-max: 18-26)			21.8	1.2
Body mass index (kg/m2) (min-max: 17.6-26.3)			22.0	2.9
Prevalence of Heel pain	134	39.5		
Prevalence of Plantar fasciitis	80	23.6		
Reported upper leg pain	49	14.5		
Reported knee pain	32	9.4		
Reported lower leg pain	56	16.5		
Reported ankle pain	43	12.7		
Reported foot pain	69	20.4		

APPENDIX B

MILITARY TRAINING PROGRAM

The 10-week military training combined between daily physical training and military skill training. The participants must perform daily physical training every day. The average times for physical training were 4 hours per day with each 2 hours in the morning and evening. In each 2 hours, the program contained running about 2 km and subsequently physical exercise which included push-up, sit-up, pull-up as well as chin-up. The running distance would be gradually increased until 4 km in the later phase of military training. Regarding the military skill training, it could be divided into 3 phases. The first phase (a 3-week period) included postural training with and without weapon, periodic road march training as well as general military subjects which consisted of theoretical knowledge and the uses of military equipment. During this phase, all conscripts were instructed to wear the sport shoe during the first phase of the military training. The second phase (a 5-week period) mainly contained the use of weapons and tactical training, for example, marksmanship training, maneuver during the day and the night, explosives throwing, camouflage and reconnaissance training. And the third phase (a 2-week period) included the individual testing of both physical fitness and military subjects. After the first phase, they were instructed to use the combat boot throughout the training period. The weight of combat boot is around 1.2 kg. It contains adhesive rubber sole, smooth leather lining with 8-hole cording, and bolstered boot.

APPENDIX C

RELIABILITY TESTING OF PHYSICAL ASSESSMENT

Prior to collecting data for the current study, we performed a pilot study to compute the intrarater reliability of all physical examination among 10 male conscripts. To determine the reliability of measurement, the test-retest reliability was calculated by the Intraclass correlation coefficient (ICC), standard error of measurement (SEM), and minimal detectable change (MDC) between two repeated measurements (145). SEM indicates the expected variation in observed data due to measurement error and MDC indicates the minimal magnitude of change beyond which the change is likely to be real, rather than due to random measurement error. It can be used as a threshold to judge whether a certain measure between groups signifies real difference (145).

Table 1 The reliability coefficient (ICC), standard error of measurement (SEM) and minimal detectable change (MDC) of each physical assessment

Physical assessment	ICC	SEM	MDC
Pelvic angle	0.88	1.7	4.7
Femoral anteversion angle	0.85	1.0	2.8
Hip abductor strength	0.85	1.8	5.0
Hip external rotator strength	0.79	2.4	6.6
Tibial torsion angle	0.70	2.9	8.0
Quadriceps angle	0.70	2.4	6.6
Knee extension angle (genu recurvatum)	0.97	0.1	0.3
Hip flexion angle (hamstring length)	0.93	2.7	7.5
Ankle plantarflexor strength (heel raising times)	0.96	0.3	0.8
Ankle DF angle with knee extension	0.92	1.6	4.4
Ankle DF angle with knee flexion	0.86	2.2	6.1
First MTP joint dorsiflexion angle	0.91	3.2	8.8
Rearfoot angle	0.93	0.7	1.9
Quality of movement scores	0.72	0.1	0.3

* Significance level at $P < .05$

Table 2 The reliability coefficient (ICC), standard error of measurement (SEM) and minimal detectable change (MDC) of each assessment

			Initial contact			Forefoot contact			Foot flat			Forefoot push off		
			ICC	SEM	MDC	ICC	SEM	MDC	ICC	SEM	MDC	ICC	SEM	MDC
Rearfoot														
Sha-Cal	Sagittal	DF/PF	0.96	0.01	0.03	0.98	0.04	0.11	0.91	0.03	0.08	0.98	0.06	0.15
	Frontal	Inv/Eve	0.96	0.12	0.33	0.98	0.01	0.02	0.96	0.03	0.07	0.79	0.26	0.71
	Transverse	Add/Abd	0.95	0.18	0.50	0.98	0.11	0.29	0.97	0.01	0.01	0.98	0.01	0.01
Midfoot														
Cal-Mid	Sagittal	DF/PF	0.91	0.00	0.01	0.81	0.03	0.09	0.98	0.00	0.01	0.98	0.04	0.11
	Frontal	Inv/Eve	0.98	0.04	0.11	0.91	0.03	0.09	0.97	0.03	0.09	0.89	0.02	0.05
	Transverse	Add/Abd	0.94	0.09	0.25	0.87	0.08	0.21	0.85	0.07	0.19	0.94	0.49	1.37
Forefoot														
Mid-Met	Sagittal	DF/PF	0.98	0.01	0.02	0.91	0.02	0.05	0.89	0.14	0.40	0.96	0.13	0.36
	Frontal	Inv/Eve	0.91	0.02	0.05	0.90	0.04	0.12	0.86	0.03	0.09	0.98	0.05	0.14
	Transverse	Add/Abd	0.91	0.02	0.05	0.88	0.04	0.11	0.95	0.02	0.04	0.98	0.04	0.11
Ankle														
	Sagittal	DF/PF	0.88	0.19	0.53	0.98	0.13	0.36	0.80	0.01	0.02	0.97	0.01	0.03
	Frontal	Inv/Eve	0.98	0.00	0.01	0.96	0.01	0.04	0.97	0.17	0.48	0.97	0.01	0.02
	Transverse	Add/Abd	0.98	0.02	0.05	0.98	0.16	0.44	0.98	0.06	0.16	0.98	0.05	0.12
Knee														
	Sagittal	E/F	0.80	0.01	0.01	0.98	0.03	0.09	0.89	0.08	0.22	0.90	0.63	1.74
	Frontal	Add/Abd	0.94	0.07	0.20	0.69	0.02	0.05	0.86	0.07	0.20	0.94	0.11	0.29
	Transverse	IR/ER	0.95	0.39	1.08	0.87	0.09	0.24	0.94	0.04	0.11	0.97	0.13	0.37
Hip														
	Sagittal	E/F	0.95	0.36	1.01	0.89	0.34	0.94	0.91	0.07	0.20	0.90	0.14	0.39
	Frontal	Add/Abd	0.91	0.17	0.48	0.67	0.02	0.05	0.68	0.02	0.05	0.98	0.26	0.72
	Transverse	IR/ER	0.67	1.85	5.12	0.93	0.01	0.02	0.95	0.01	0.02	0.97	0.38	1.04

APPENDIX D

SAMPLE SIZE CALCULATION

Study 1

According to the rule of thumb, the sample size (N) was calculated from the formula below (118).

$$\text{Sample size (N)} = 50 + 8m$$

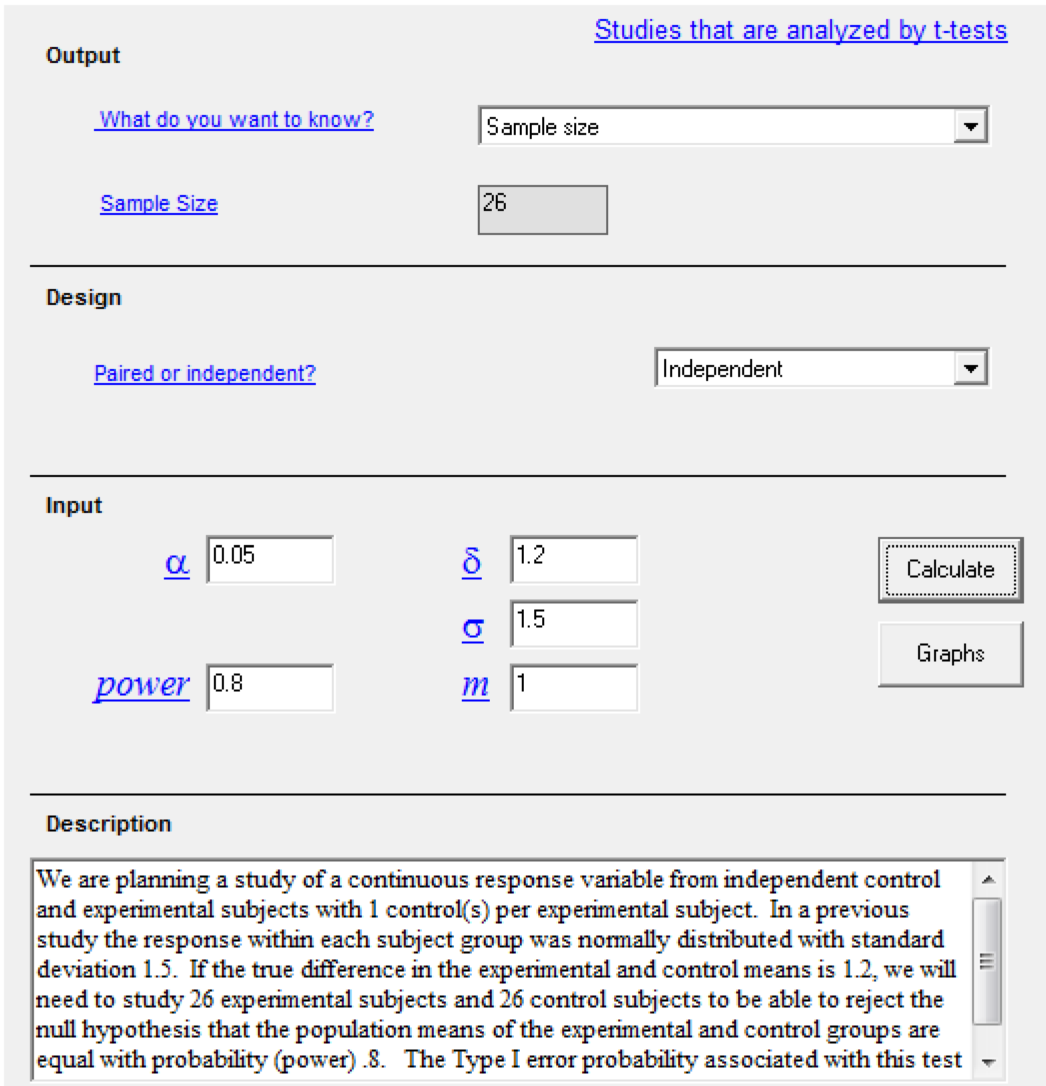
When m is the number of predictors i.e. 17, the sample size thus should be at least 186 participants to achieve 80% power from the regression analysis.

Study 2

According to the rule of thumb (118), the sample size (N) should be at least 106 participants to achieve 80% power from the regression analysis, when the number of predictors was 7.

Study 3

According to the results from previous study, they reported the significant difference of total rearfoot motion during the stance phase of gait cycle between the plantar fasciitis group and the control group with 1.2 ° ± 1.5 ° (means ± standard deviation) (21). As a result, the kinematics data was used to calculate sample size for Independent T-test (α = 0.05, β = 0.80) using a power and sample size calculation program (PS software) as shown in the figure below.


Studies that are analyzed by t-tests
Output
What do you want to know?
Sample size
Sample Size
26
Design
Paired or independent?
Independent
Input
α
0.05
δ
1.2
σ
1.5
power
0.8
m
1
Calculate
Graphs
Description
We are planning a study of a continuous response variable from independent control and experimental subjects with 1 control(s) per experimental subject. In a previous study the response within each subject group was normally distributed with standard deviation 1.5. If the true difference in the experimental and control means is 1.2, we will need to study 26 experimental subjects and 26 control subjects to be able to reject the null hypothesis that the population means of the experimental and control groups are equal with probability (power) .8. The Type I error probability associated with this test

APPENDIX E

QUESTIONNAIRE FOR STUDY 1 & 2

แบบสอบถามอาการบาดเจ็บทางระบบกระดูกและกล้ามเนื้อส่วนขา ทบ.1/59 (ครั้งที่ 1)

อายุ................ปี น้ำหนัก............กิโลกรัม ส่วนสูง..............เซนติเมตร

ขาข้างที่ถนัด ☐ ซ้าย ☐ ขวา

เบอร์โทรศัพท์ที่ติดต่อได้...

คำชี้แจง

- แบบสอบถามนี้แบ่งออกเป็น 4 ส่วน จำนวน 5 หน้า ได้แก่

  <u>ส่วนที่ 1</u> ข้อมูลทางด้านสุขภาพและการออกกำลัง

  <u>ส่วนที่ 2</u> ข้อมูลอาการปวดส้นเท้า

  <u>ส่วนที่ 3</u> ข้อมูลอาการปวดทางระบบกระดูกและกล้ามเนื้อส่วนหลังบั้นเอวและรยางค์ขา

  <u>ส่วนที่ 4</u> ข้อมูลทางด้านจิตใจ

- กรุณาตอบคำถามทุกข้อตามความเป็นจริง โดยเลือกเพียงคำตอบเดียว หรือใส่ข้อความสั้นๆ ที่ตรงกับตัวท่านมากที่สุด
- ในบางคำถามสามารถเลือกตอบได้มากกว่า 1 คำตอบ ซึ่งจะระบุไว้ในท้ายของคำถามข้อนั้น

ขอขอบพระคุณท่านเป็นอย่างสูงในการให้ความร่วมมือค่ะ

<u>ส่วนที่ 1</u> ข้อมูลทางด้านสุขภาพและการออกกำลัง

คำชี้แจง กรุณาตอบคำถามทุกข้อตามความเป็นจริง โดยใส่ข้อความลงในช่องว่าง หรือเลือกคำตอบที่สอดคล้องกับความคิดเห็นของท่านมากที่สุด โดยใส่เครื่องหมาย ✓ ใน [....]

---

1) ท่านมีโรคประจำตัวหรือไม่

[....] ไม่มีโรคประจำตัวใดๆ

[....] มีภาวะหรือโรคดังต่อไปนี้ (ตอบได้มากกว่า 1 ข้อ)

[....] มีปัญหาความผิดปกติของระบบในร่างกายจากการวินิจฉัยของแพทย์ เช่น การมีเนื้องอก หรือการติดเชื้อ ซึ่งอยู่ในระหว่างการรักษาจากแพทย์ผู้เชี่ยวชาญเฉพาะทาง

[....] มีประวัติเคยผ่าตัดบริเวณรยางค์ขา โปรดระบุ..

[....] เคยมีการหักของกระดูกบริเวณรยางค์ขา โปรดระบุบริเวณที่หัก................

[....] ได้รับการวินิจฉัยจากแพทย์ว่ามีโรคดังต่อไปนี้ โรคเกาท์ หรือโรคมะเร็งกระดูก หรือโรคเบาหวานที่มีอาการชาเท้า หรือโรคกระดูกอักเสบ เช่น รูมาตอยด์

[....] อื่นๆ โปรดระบุ..

2) โปรดประเมินกิจกรรมการเคลื่อนไหวร่างกายของท่าน *<u>ในช่วง 1 ปีที่ผ่านมา</u>*

2.1 เมื่อเปรียบเทียบกับคนอื่น ท่านคิดว่ากิจกรรมการเคลื่อนไหวร่างกายในยามว่างนั้น

[....] มากกว่ามาก [....] มากกว่า [....] พอๆกัน [....] น้อยกว่า [....] น้อยกว่ามาก

2.2 ช่วงเวลาว่าง ท่านเหงื่อออก

[....] บ่อยมาก [....] บ่อย [....] บางครั้ง [....] ไม่บ่อย [....] ไม่เคย

2.3 ช่วงเวลาว่าง ท่านเล่นกีฬา

[....] บ่อยมาก [....] บ่อย [....] บางครั้ง [....] ไม่บ่อย [....] ไม่เคย

2.4 โปรดระบุกีฬาที่ท่านเล่นบ่อยที่สุดอันดับที่ 1..

2.5 ท่านเล่นกีฬาในข้อ 2.4 บ่อยแค่ไหน (กี่ชั่วโมงต่อสัปดาห์)

[....] น้อยกว่า 1 ชั่วโมง [....] 1-2 ชั่วโมง [....] 2-3 ชั่วโมง

[....] 3-4 ชั่วโมง [....] มากกว่า 4 ชั่วโมง

2.6 ระยะเวลาที่ท่านเล่นกีฬาในข้อ 2.4 (กี่เดือนต่อปี)

[....] น้อยกว่า 1 เดือน [....] 1-3 เดือน [....] 4-6 เดือน [....] 7-9 เดือน [....] มากกว่า 9 เดือน

2.7 โปรดระบุกีฬาที่ท่านเล่นบ่อยที่สุดอันดับที่ 2..

2.8 ท่านเล่นกีฬาในข้อ 2.7 บ่อยแค่ไหน (กี่ชั่วโมงต่อสัปดาห์)

[....] น้อยกว่า 1 ชั่วโมง [....] 1-2 ชั่วโมง [....] 2-3 ชั่วโมง

[....] 3-4 ชั่วโมง [....] มากกว่า 4 ชั่วโมง

2.9 ระยะเวลาที่ท่านเล่นกีฬาในข้อ 2.7 (กี่เดือนต่อปี)

[....] น้อยกว่า 1 เดือน [....] 1-3 เดือน [....] 4-6 เดือน [....] 7-9 เดือน [....] มากกว่า 9 เดือน

<u>ส่วนที่ 2</u> ข้อมูลอาการปวดส้นเท้า

คำชี้แจง กรุณาตอบคำถามทุกข้อตามความเป็นจริง โดยใส่ข้อความลงในช่องว่าง หรือเลือกคำตอบที่สอดคล้องกับความคิดเห็นของท่านมากที่สุด โดยใส่เครื่องหมาย ✓ ใน [....]

---

1) ***<u>ในรอบ 1 สัปดาห์ที่ผ่านมา</u>*** ท่านมีอาการ***ปวดส้นเท้า*** หรือไม่

[....] ไม่ใช่ [....] ใช่ โปรดระบุข้าง ☐ ซ้าย ☐ ขวา ☐ ทั้ง 2 ข้าง

2) ท่านมีอาการปวดส้นเท้าในรอบปัจจุบันมาเป็นระยะเวลา.....ปี........เดือน.........สัปดาห์

3) ท่านมีลักษณะของอาการปวดส้นเท้าแบบตุบๆ ปวดแสบ หรือปวดแปล๊บหรือไม่

[....] ไม่ใช่ [....] ใช่ [....] อื่นๆ โปรดระบุ......................

4) ท่านมีอาการปวดและจุดกดเจ็บที่ส้นเท้าด้านใน (ดังรูป) หรือไม่

[....] ไม่ใช่ [....] ใช่ [....] อื่นๆ โปรดระบุ.......................

5) อาการปวดส้นเท้าของท่านมีลักษณะค่อยๆ เกิดขึ้น และมักเกิดอาการปวดเมื่อท่านลุกขึ้นจากเตียงหลังตื่นนอน ตอนเช้า หรือหลังจากหยุดพักกิจกรรมที่มีการลงน้ำหนักเป็นเวลานานหรือไม่

[....] ไม่ใช่ [....] ใช่ [....] อื่นๆ โปรดระบุ...

6) อาการปวดส้นเท้าของท่านในตอนเช้าลดลงหลังเดินสักระยะหนึ่ง และมีอาการรุนแรงมากขึ้นในตอนเย็นหลังผ่าน การใช้งานระหว่างวัน โดยอาการปวดมักเป็นมากขึ้นเมื่อเดินเท้าเปล่า ขึ้นบันได หรือเดินด้วยปลายเท้าหรือไม่

[....] ไม่ใช่ [....] ใช่ [....] อื่นๆ โปรดระบุ...

7) ท่านคิดว่าอาการปวดส้นเท้าของท่านเกิดจากสาเหตุใด

[....] การฝึกทางทหาร โปรดระบุ...

[....] การเล่นกีฬา โปรดระบุ...

[....] อื่นๆ โปรดระบุ...

8) ท่านจัดการกับอาการปวดส้นเท้าดังกล่าวด้วย***วิธีการใด*** และ***ผลเป็นอย่างไร*** โปรดระบุ

....

9) **อาการปวดส้นเท้าในรอบ 1 สัปดาห์ที่ผ่านมาครั้งที่รุนแรงที่สุด<u>มีระดับความรุนแรงเท่ากับเท่าไหร่</u>** ขอให้ทำเครื่องหมาย X ลงบนเส้นตรงด้านล่าง ที่คิดว่ามีระดับความปวดตรงกับตัวท่าน โดยหมายเลข 0 หมายถึง *ไม่มีอาการปวดเลย* และหมายเลข 10 หมายถึง *มีอาการปวดมากที่สุดจนทนไม่ได้* ยิ่งเครื่องหมาย X อยู่ทางขวายิ่งหมายถึงปวดมาก

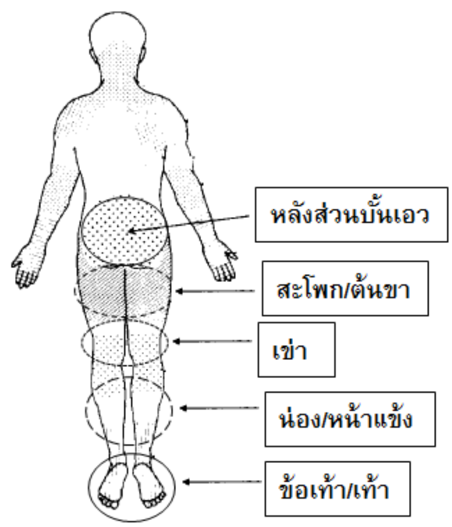
0 ____ 10

ไม่ปวด ปวดมากที่สุด

<u>ส่วนที่ 3</u> ข้อมูลอาการปวดทางระบบกระดูกและกล้ามเนื้อส่วนหลังบั้นเอวและระยางค์ขา

คำชี้แจง ขอให้ทำเครื่องหมาย X ลงบนเส้นตรงด้านล่าง ที่คิดว่ามีระดับความปวดตรงกับตัวท่าน โดยหมายเลข 0 หมายถึง *ไม่มีอาการปวดเลย* และหมายเลข 10 หมายถึง *มีอาการปวดมากที่สุดจนทนไม่ได้* ยิ่งเครื่องหมาย X อยู่ทางขวายิ่งหมายถึงปวดมาก

<u>ในรอบ 3 เดือนที่ผ่านมา</u> ท่านเคยมีอาการปวด ความรู้สึกไม่สบาย หรือความรู้สึกที่ไม่ปกติ (เช่น ผิวหนังชา หรือขาอ่อนแรง เป็นต้น) เป็นเวลานานอย่างน้อย 1 วัน ในบริเวณดังรูปหรือไม่



1) หลังส่วนบั้นเอว

0 ____ 10
ไม่ปวด ปวดมากที่สุด

2) สะโพก/ต้นขา

0 ____ 10
ไม่ปวด ปวดมากที่สุด

3) เข่า

0 ____ 10
ไม่ปวด ปวดมากที่สุด

4) น่อง/หน้าแข้ง

0 ____ 10
ไม่ปวด ปวดมากที่สุด

5) ข้อเท้า/เท้า

0 ____ 10
ไม่ปวด ปวดมากที่สุด

ส่วนที่ 4 ข้อมูลทางด้านจิตใจ

คำชี้แจง โปรดอ่านข้อความแต่ละข้อและวงกลมหมายเลข 0, 1, 2 หรือ 3 เพียง 1 คำตอบที่ระบุข้อความได้ตรงกับท่านมากที่สุด***ในช่วงสัปดาห์ที่ผ่านมา***

หัวข้อ	ระดับความคิดเห็น			
	ไม่เลย	บางครั้ง	ค่อนข้างบ่อย	เกือบตลอดเวลา
ฉันรู้สึกว่ายากที่จะผ่อนคลายอารมณ์				
ฉันทราบว่าฉันมีอาการปากแห้ง				
ฉันรู้สึกไม่ดีขึ้นเลย				
ฉันมีอาการหายใจลำบาก (เช่น มีอาการหายใจเร็วขึ้นผิดปกติ มีอาการหายใจไม่ออกแม้ว่าจะไม่ได้ออกแรง)				
ฉันรู้สึกทำกิจกรรมด้วยตนเองได้ค่อนข้างลำบาก				
ฉันเริ่มมีปฏิกิริยาตอบสนองต่อสิ่งต่าง ๆ มากเกินไป				
ฉันมีอาการสั่น (เช่น ที่มือทั้งสองข้าง)				
ฉันรู้สึกว่าฉันวิตกกังวลมาก				
ฉันรู้สึกกังวลกับเหตุการณ์ที่อาจทำให้ฉันรู้สึกตื่นกลัวและกระทำสิ่งใดโดยมิได้คิด				
ฉันรู้สึกว่าฉันไม่มีเป้าหมาย				
ฉันเริ่มรู้สึกว่าฉันมีอาการกระวนกระวายใจ				
ฉันรู้สึกไม่ผ่อนคลาย				
ฉันรู้สึกจิตใจเหงาหงอยและเศร้าซึม				
ฉันทนไม่ได้กับภาวะใดก็ตามที่ทำให้ฉันไม่สามารถทำอะไรต่อจากที่ฉันกำลังกระทำอยู่				

หัวข้อ	ระดับความคิดเห็น			
	ไม่เลย	บางครั้ง	ค่อนข้างบ่อย	เกือบตลอดเวลา
ฉันรู้สึกว่าฉันมีอาการคล้ายกับอาการหวั่นวิตก				
ฉันไม่รู้สึกกระตือรือร้นต่อสิ่งใด				
ฉันรู้สึกเป็นคนไม่มีคุณค่า				
ฉันรู้สึกว่าฉันค่อนข้างมีอารมณ์ฉุนเฉียวง่าย				
ฉันรับรู้ถึงการทำงานของหัวใจของฉันในตอนที่ฉันไม่ได้ออกแรง (เช่น รู้สึกถึงการเต้นของหัวใจเพิ่มขึ้น การหยุดเต้นของหัวใจ)				
ฉันรู้สึกกลัวโดยไม่มีเหตุผลใด ๆ				
ฉันรู้สึกว่าชีวิตไม่มีความหมาย				

แบบสอบถามอาการบาดเจ็บทางระบบกระดูกและกล้ามเนื้อส่วนขา ทบ.1/59 (ครั้งที่ 2)

อายุ...............ปี น้ำหนัก...........กิโลกรัม ส่วนสูง.............เซนติเมตร

ข้างที่ถนัด ☐ ซ้าย ☐ ขวา

เบอร์โทรศัพท์ที่ติดต่อได้..

คำชี้แจง

- แบบสอบถามนี้แบ่งออกเป็น 2 ส่วน จำนวน 2 หน้า ได้แก่
  ส่วนที่ 1 ข้อมูลอาการปวดส้นเท้า
  ส่วนที่ 2 ข้อมูลอาการปวดทางระบบกระดูกและกล้ามเนื้อส่วนหลังบั้นเอวและรยางค์ขา
  ส่วนที่ 3 ข้อมูลทางด้านจิตใจ

- กรุณาตอบคำถามทุกข้อตามความเป็นจริง โดยเลือกเพียงคำตอบเดียว หรือใส่ข้อความสั้นๆ ที่ตรงกับตัวท่านมากที่สุด
- ในบางคำถามสามารถเลือกตอบได้มากกว่า 1 คำตอบ ซึ่งจะระบุไว้ในท้ายของคำถามข้อนั้น

ขอขอบพระคุณท่านเป็นอย่างสูงในการให้ความร่วมมือค่ะ

<u>ส่วนที่ 1</u> ข้อมูลอาการปวดส้นเท้า

คำชี้แจง กรุณาตอบคำถามทุกข้อตามความเป็นจริง โดยใส่ข้อความลงในช่องว่าง หรือเลือกคำตอบที่สอดคล้องกับความคิดเห็นของท่านมากที่สุด โดยใส่เครื่องหมาย ✓ ใน [....]

1) ***<u>ในรอบ 1 สัปดาห์ที่ผ่านมา</u>*** ท่านมีอาการ***ปวดส้นเท้า*** หรือไม่

[....] ไม่ใช่ [....] ใช่ โปรดระบุข้าง ☐ ซ้าย ☐ ขวา ☐ ทั้ง 2 ข้าง

2) ท่านมีอาการปวดส้นเท้าในรอบปัจจุบันมาเป็นระยะเวลา.......ปี.........เดือน.........สัปดาห์

3) ท่านมีลักษณะของอาการปวดส้นเท้าแบบตุบๆ ปวดแสบ หรือปวดแปล๊บหรือไม่

[....] ไม่ใช่ [....] ใช่ [....] อื่นๆ โปรดระบุ............................

4) ท่านมีอาการปวดและจุดกดเจ็บที่ส้นเท้าด้านใน (ดังรูป) หรือไม่

[....] ไม่ใช่ [....] ใช่ [....] อื่นๆ โปรดระบุ............................

5) อาการปวดส้นเท้าของท่านมีลักษณะค่อยๆ เกิดขึ้น และมักเกิดอาการปวดเมื่อท่านลุกขึ้นจากเตียงหลังตื่นนอน ตอนเช้า หรือหลังจากหยุดพักกิจกรรมที่มีการลงน้ำหนักเป็นเวลานานหรือไม่

[....] ไม่ใช่ [....] ใช่ [....] อื่นๆ โปรดระบุ..

6) อาการปวดส้นเท้าของท่านในตอนเช้าลดลงหลังเดินสักระยะหนึ่ง และมีอาการรุนแรงมากขึ้นในตอนเย็นหลังผ่าน การใช้งานระหว่างวัน โดยอาการปวดมักเป็นมากขึ้นเมื่อเดินเท้าเปล่า ขึ้นบันได หรือเดินด้วยปลายเท้าหรือไม่

[....] ไม่ใช่ [....] ใช่ [....] อื่นๆ โปรดระบุ..

7) ท่านคิดว่าอาการปวดส้นเท้าของท่านเกิดจากสาเหตุใด

[....] การฝึกทางทหาร โปรดระบุ...

[....] การเล่นกีฬา โปรดระบุ...

[....] อื่นๆ โปรดระบุ..

8) ท่านจัดการกับอาการปวดส้นเท้าดังกล่าวด้วย***วิธีการใด*** และ***ผลเป็นอย่างไร*** โปรดระบุ

....

9) **อาการปวดส้นเท้าในรอบ 1 สัปดาห์ที่ผ่านมาครั้งที่รุนแรงที่สุด<u>มีระดับความรุนแรงเท่ากับเท่าไหร่</u>** ขอให้ทำเครื่องหมาย X ลงบนเส้นตรงด้านล่าง ที่คิดว่ามีระดับความปวดตรงกับตัวท่าน โดยหมายเลข 0 หมายถึง *ไม่มีอาการปวดเลย* และหมายเลข 10 หมายถึง *มีอาการปวดมากที่สุดจนทนไม่ได้* ยิ่งเครื่องหมาย X อยู่ทางขวายิ่งหมายถึงปวดมาก

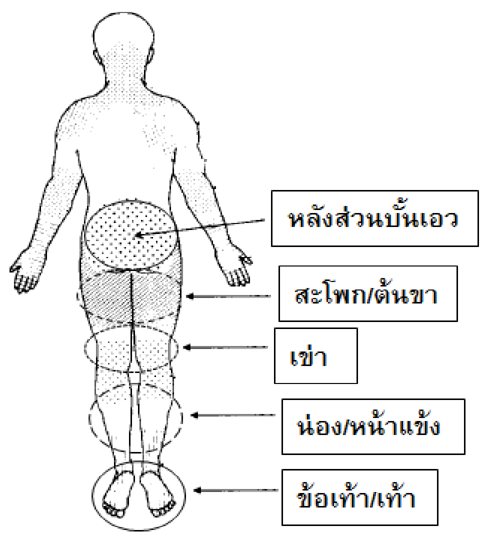
0 ———————————————————— 10

ไม่ปวด ปวดมากที่สุด

ส่วนที่ 2 ข้อมูลอาการปวดทางระบบกระดูกและกล้ามเนื้อส่วนหลังบั้นเอวและระยางค์ขา

คำชี้แจง ขอให้ทำเครื่องหมาย X ลงบนเส้นตรงด้านล่าง ที่คิดว่ามีระดับความปวดตรงกับตัวท่าน โดยหมายเลข 0 หมายถึง *ไม่มีอาการปวดเลย* และหมายเลข 10 หมายถึง *มีอาการปวดมากที่สุดจนทนไม่ได้* ยิ่งเครื่องหมาย X อยู่ทางขวายิ่งหมายถึงปวดมาก

ในรอบ 1 สัปดาห์ที่ผ่านมา ท่านเคยมีอาการปวด ความรู้สึกไม่สบาย หรือความรู้สึกที่ไม่ปกติ (เช่น ผิวหนังชา หรือขาอ่อนแรง เป็นต้น) เป็นเวลานานอย่างน้อย 1 วัน ในบริเวณดังรูปหรือไม่



1) หลังส่วนบั้นเอว

0 ____ 10

ไม่ปวด ปวดมากที่สุด

2) สะโพก/ต้นขา

0 ____ 10

ไม่ปวด ปวดมากที่สุด

3) เข่า

0 ____ 10

ไม่ปวด ปวดมากที่สุด

4) น่อง/หน้าแข้ง

0 ____ 10

ไม่ปวด ปวดมากที่สุด

5) ข้อเท้า/เท้า

0 ____ 10

ไม่ปวด ปวดมากที่สุด

<u>ส่วนที่ 3</u> ข้อมูลทางด้านจิตใจ

คำชี้แจง โปรดอ่านข้อความแต่ละข้อและวงกลมหมายเลข 0, 1, 2 หรือ 3 เพียง 1 คำตอบที่ระบุข้อความได้ตรงกับท่านมากที่สุด***<u>ในช่วงสัปดาห์ที่ผ่านมา</u>***

หัวข้อ	ระดับความคิดเห็น			
	ไม่เลย	บางครั้ง	ค่อนข้างบ่อย	เกือบตลอดเวลา
ฉันรู้สึกว่ายากที่จะผ่อนคลายอารมณ์				
ฉันทราบว่าฉันมีอาการปากแห้ง				
ฉันรู้สึกไม่ดีขึ้นเลย				
ฉันมีอาการหายใจลำบาก (เช่น มีอาการหายใจเร็วขึ้นผิดปกติ มีอาการหายใจไม่ออกแม้ว่าจะไม่ได้ออกแรง)				
ฉันรู้สึกทำกิจกรรมด้วยตนเองได้ค่อนข้างลำบาก				
ฉันเริ่มมีปฏิกิริยาตอบสนองต่อสิ่งต่าง ๆ มากเกินไป				
ฉันมีอาการสั่น (เช่น ที่มือทั้งสองข้าง)				
ฉันรู้สึกว่าฉันวิตกกังวลมาก				
ฉันรู้สึกกังวลกับเหตุการณ์ที่อาจทำให้ฉันรู้สึกตื่นกลัวและกระทำสิ่งใดโดยมิได้คิด				
ฉันรู้สึกว่าฉันไม่มีเป้าหมาย				
ฉันเริ่มรู้สึกว่าฉันมีอาการกระวนกระวายใจ				
ฉันรู้สึกไม่ผ่อนคลาย				
ฉันรู้สึกจิตใจเหงาหงอยและเศร้าซึม				
ฉันทนไม่ได้กับภาวะใดก็ตามที่ทำให้ฉันไม่สามารถทำอะไรต่อจากที่ฉันกำลังกระทำอยู่				

หัวข้อ	ระดับความคิดเห็น			
	ไม่เลย	บางครั้ง	ค่อนข้างบ่อย	เกือบตลอดเวลา
ฉันรู้สึกว่าฉันมีอาการคล้ายกับอาการหวั่นวิตก				
ฉันไม่รู้สึกกระตือรือร้นต่อสิ่งใด				
ฉันรู้สึกเป็นคนไม่มีคุณค่า				
ฉันรู้สึกว่าฉันค่อนข้างมีอารมณ์ฉุนเฉียวง่าย				
ฉันรับรู้ถึงการทำงานของหัวใจของฉันในตอนที่ฉันไม่ได้ออกแรง (เช่น รู้สึกถึงการเต้นของหัวใจเพิ่มขึ้น การหยุดเต้นของหัวใจ)				
ฉันรู้สึกกลัวโดยไม่มีเหตุผลใด ๆ				
ฉันรู้สึกว่าชีวิตไม่มีความหมาย				

APPENDIX F

SCREENING QUESTIONNAIRE FOR STUDY 3

แบบคัดกรอง

อายุ...............ปี น้ำหนัก...........กิโลกรัม ส่วนสูง.............เซนติเมตร

คำชี้แจง กรุณาตอบคำถามทุกข้อตามความเป็นจริง โดยใส่ข้อความลงในช่องว่าง หรือเลือกคำตอบที่สอดคล้องกับความคิดเห็นของท่านมากที่สุด โดยใส่เครื่องหมาย ✓ ใน [....]

ก) ท่านมีโรคประจำตัวหรือไม่

[....] ไม่มีโรคประจำตัวใดๆ

[....] มีภาวะหรือโรคดังต่อไปนี้ (ตอบได้มากกว่า 1 ข้อ)

[....] มีปัญหาความผิดปกติของระบบในร่างกายจากการวินิจฉัยของแพทย์ เช่น การมีเนื้องอกหรือการติดเชื้อ ซึ่งอยู่ในระหว่างการรักษาจากแพทย์ผู้เชี่ยวชาญเฉพาะทาง

[....] มีประวัติเคยผ่าตัดบริเวณรยางค์ขา โปรดระบุ...

[....] เคยมีการหักของกระดูกบริเวณรยางค์ขา โปรดระบุบริเวณที่หัก................

[....] ได้รับการวินิจฉัยจากแพทย์ว่ามีโรคดังต่อไปนี้ โรคเกาท์ หรือโรคมะเร็งกระดูก หรือโรคเบาหวานที่มีอาการชาเท้า หรือโรคกระดูกอักเสบ เช่น รูมาตอยด์

[....] อื่นๆ โปรดระบุ...

ข) ข้อมูลอาการปวดส้นเท้า

1) **<u>ในรอบ 1 สัปดาห์ที่ผ่านมา</u>** ท่านมีอาการ***ปวดส้นเท้า*** หรือไม่

[....] ไม่ใช่ [....] ใช่ โปรดระบุข้าง ☐ ซ้าย ☐ ขวา ☐ ทั้ง 2 ข้าง

2) ท่านมีอาการปวดส้นเท้าในรอบปัจจุบันมาเป็นระยะเวลา.......ปี........เดือน..........สัปดาห์

3) ท่านมีลักษณะของอาการปวดส้นเท้าแบบตุบๆ ปวดแสบ หรือปวดแปล๊บหรือไม่

[....] ไม่ใช่ [....] ใช่ [....] อื่นๆ โปรดระบุ.........................

4) ท่านมีอาการปวดและจุดกดเจ็บที่ส้นเท้าด้านใน (ดังรูป) หรือไม่

[....] ไม่ใช่ [....] ใช่ [....] อื่นๆ โปรดระบุ........................

5) อาการปวดส้นเท้าของท่านมีลักษณะค่อยๆ เกิดขึ้น และมักเกิดอาการปวดเมื่อท่านลุกขึ้นจากเตียงหลังตื่นนอนตอนเช้า หรือหลังจากหยุดพักกิจกรรมที่มีการลงน้ำหนักเป็นเวลานานหรือไม่

[....] ไม่ใช่ [....] ใช่ [....] อื่นๆ โปรดระบุ..

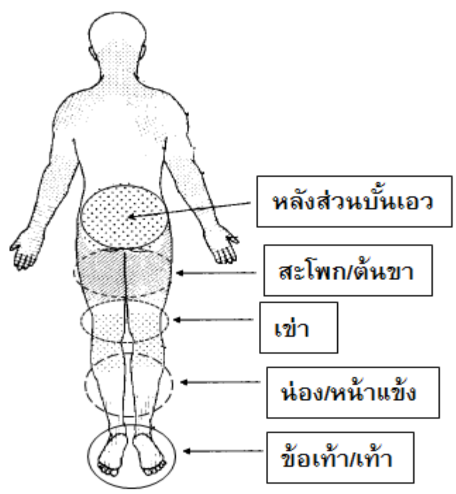
6) อาการปวดส้นเท้าของท่านในตอนเช้าลดลงหลังเดินสักระยะหนึ่ง และมีอาการรุนแรงมากขึ้นในตอนเย็นหลังผ่านการใช้งานระหว่างวัน โดยอาการปวดมักเป็นมากขึ้นเมื่อเดินเท้าเปล่า ขึ้นบันได หรือเดินด้วยปลายเท้าหรือไม่

[....] ไม่ใช่ [....] ใช่ [....] อื่นๆ โปรดระบุ..

คำชี้แจง ขอให้ทำเครื่องหมาย X ลงบนเส้นตรงด้านล่าง ที่คิดว่ามีระดับความปวดตรงกับตัวท่าน โดยหมายเลข 0 หมายถึง *ไม่มีอาการปวดเลย* และหมายเลข 10 หมายถึง *มีอาการปวดมากที่สุดจนทนไม่ได้* ยิ่งเครื่องหมาย X อยู่ทางขวายิ่งหมายถึงปวดมาก

ค) ข้อมูลอาการปวดทางระบบกระดูกและกล้ามเนื้อส่วนหลังบั้นเอวและรยางค์ขา

ในรอบ 1 สัปดาห์ที่ผ่านมา ท่านเคยมีอาการปวด ความรู้สึกไม่สบาย หรือความรู้สึกที่ไม่ปกติ (เช่น ผิวหนังชา หรือขาอ่อนแรง เป็นต้น) เป็นเวลานานอย่างน้อย 1 วัน ในบริเวณดังรูปหรือไม่



1) หลังส่วนบั้นเอว

0 ______________________________ 10

ไม่ปวด ปวดมากที่สุด

2) สะโพก/ต้นขา

0 ______________________________ 10

ไม่ปวด ปวดมากที่สุด

3) เข่า

0 ______________________________ 10

ไม่ปวด ปวดมากที่สุด

4) น่อง/หน้าแข้ง

0 ______________________________ 10

ไม่ปวด ปวดมากที่สุด

5) ข้อเท้า/เท้า

0 ______________________________ 10

ไม่ปวด ปวดมากที่สุด

APPENDIX G

CERTIFICATE OF ETHIC APPROVAL

AF 02-12

The Research Ethics Review Committee for Research Involving Human Research Participants, Health Sciences Group, Chulalongkorn University
Jamjuree 1 Building, 2nd Floor, Phyathai Rd., Patumwan district, Bangkok 10330, Thailand,
Tel/Fax: 0-2218-3202 E-mail: eccu@chula.ac.th

COA No. 077/2016

Certificate of Approval

Study Title No. 037.1/59 : ANATOMICAL AND BIOMECHANICAL FACTORS ASSOCIATED WITH PLANTAR FASCIITIS IN THAI MALE CONSCRIPTS

Principal Investigator : MISS PAVINEE HARUTAICHUN

Place of Proposed Study/Institution : Faculty of Allied Health Sciences, Chulalongkorn University

The Research Ethics Review Committee for Research Involving Human Research Participants, Health Sciences Group, Chulalongkorn University, Thailand, has approved constituted in accordance with the International Conference on Harmonization – Good Clinical Practice (ICH-GCP).

Signature: Prida Tasanapradit Signature: Nuntaree Chaichanawongsaroj

(Associate Professor Prida Tasanapradit, M.D.)
Chairman

(Assistant Professor Nuntaree Chaichanawongsaroj, Ph.D.)
Secretary

Date of Approval : 18 April 2016 Approval Expire date : 17 April 2017

The approval documents including

1) Research proposal
2) Patient/Participant Information Sheet and Informed Consent Form
3) Researcher
4) Questionnaire

Protocol No. 037.1/59
Date of Approval 18 APR 2016
Approval Expire Date 17 APR 2017

The approved investigator must comply with the following conditions:

1. *The research/project activities must end on the approval expired date of the Research Ethics Review Committee for Research Involving Human Research Participants, Health Sciences Group, Chulalongkorn University (RECCU). In case the research/project is unable to complete within that date, the project extension can be applied one month prior to the RECCU approval expired date.*
2. *Strictly conduct the research/project activities as written in the proposal.*
3. *Using only the documents that bearing the RECCU's seal of approval with the subjects/volunteers (including subject information sheet, consent form, invitation letter for project/research participation (if available).*
4. *Report to the RECCU for any serious adverse events within 5 working days*
5. *Report to the RECCU for any change of the research/project activities prior to conduct the activities.*
6. *Final report (AF 03-12) and abstract is required for a one year (or less) research/project and report within 30 days after the completion of the research/project. For thesis, abstract is required and report within 30 days after the completion of the research/project.*
7. *Annual progress report is needed for a two- year (or more) research/project and submit the progress report before the expire date of certificate. After the completion of the research/project processes as No. 6.*

APPENDIX H
INFORMATION SHEET FOR STUDY 1 & 2

ข้อมูลสำหรับกลุ่มประชากรหรือผู้มีส่วนร่วมในการวิจัย

ชื่อโครงการวิจัย *ปัจจัยทางกายวิภาคศาสตร์และชีวกลศาสตร์ที่มีความสัมพันธ์กับภาวะเอ็นรองฝ่าเท้าอักเสบในกลุ่มทหารเกณฑ์เพศชายชาวไทย*
ผู้วิจัยหลัก นางสาวภาวิณี หฤทัยชื่น ตำแหน่ง นิสิตปริญญาเอก

สถานที่ติดต่อผู้วิจัย (นางสาวภาวิณี หฤทัยชื่น)
หน่วยงาน/สถาบัน ภาควิชากายภาพบำบัด คณะสหเวชศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
ที่อยู่ 492/34 ถนนสุขสวัสดิ์ เขตราษฎร์บูรณะ กรุงเทพฯ 10140
โทรศัพท์มือถือ 086-514-1564 E-mail: pavinee.h24@gmail.com

เรียน อาสาสมัครทุกท่าน

ท่านได้รับเชิญให้เป็นผู้มีส่วนร่วมในการวิจัยนี้ ก่อนที่ท่านจะตัดสินใจเข้าร่วมในการวิจัยนี้ มีความจำเป็นที่ท่านควรทำความเข้าใจว่า งานวิจัยนี้ทำเพราะเหตุใด และเกี่ยวข้องกับอะไร กรุณาใช้เวลาในการอ่านข้อมูลต่อไปนี้อย่างละเอียดรอบคอบ และสอบถามข้อมูลเพิ่มเติมหรือข้อมูลที่ไม่ชัดเจนได้ตลอดเวลา

โครงการนี้เกี่ยวข้องกับการวิจัยอะไร

โครงการวิจัยนี้เป็นการศึกษาเพื่อหาปัจจัยเสี่ยงที่เกี่ยวข้องกับการเกิดอาการปวดส้นเท้าจากภาวะเอ็นรองฝ่าเท้าอักเสบในกลุ่มทหารเกณฑ์ชาวไทย โดยจะมีการตรวจประเมินร่างกายทางกายภาพบำบัดเพื่อหาปัจจัยเสี่ยงดังกล่าว

สถานที่ดำเนินการวิจัย

หน่วยฝึกทหารใหม่จำนวน 3 หน่วย ประกอบด้วย กองพันทหารราบ มณฑลทหารบกที่ 11 (พัน.ร.มทบ.11), กองร้อยกองบังคับการ กองพันทหารราบ มณฑลทหารบกที่ 11 (บก.มทบ.11) และ ส่วนสนับสนุนกองบัญชาการกองทัพบก (สสน.บก.ทบ.) จังหวัดกรุงเทพมหานคร

รายละเอียดของกลุ่มประชากรหรือผู้มีส่วนร่วมในการวิจัย

โครงการวิจัยนี้ทำการศึกษาในอาสาสมัครจำนวนทั้งสิ้น 334 คน โดยมีระยะเวลาในการดำเนินงานวิจัย 3 เดือน ท่านได้รับเชิญเข้าร่วมการวิจัยนี้ หากท่านมีคุณสมบัติดังนี้

- เป็นทหารเกณฑ์ชาวไทยที่เข้ารับการฝึกพื้นฐานทางทหารเป็นระยะเวลา 10 สัปดาห์ ระหว่างเดือนพฤษภาคมถึงเดือนกรกฎาคมปี พ.ศ. 2559
- มีอายุระหว่าง 20-27 ปี
- ไม่มีอาการปวด หรือความรู้สึกที่ไม่สบาย หรือความรู้สึกที่ไม่ปกติ (เช่น ผิวหนังชา หรือขาอ่อนแรง เป็นต้น) ของหลังส่วนบั้นเอว สะโพก/ต้นขา เข่า น่อง/หน้าแข้ง ข้อเท้า/เท้า ภายในระยะเวลา 3 เดือนที่ผ่านมา
- ไม่เคยได้รับการผ่าตัดของกระดูกขามาก่อน
- ไม่เคยมีการหักของกระดูกขา
- ไม่มีปัญหาความผิดปกติของระบบในร่างกายจากการวินิจฉัยของแพทย์ เช่น การมีเนื้องอก หรือการติดเชื้อ ซึ่งอยู่ในระหว่างการรักษาจากแพทย์ผู้เชี่ยวชาญเฉพาะทาง
- ไม่ได้รับการวินิจฉัยจากแพทย์ว่ามีโรคดังต่อไปนี้ โรคเกาท์ หรือโรคมะเร็งกระดูก หรือโรคเบาหวานที่มีอาการชาเท้า หรือโรคกระดูกอักเสบ เช่น รูมาตอยด์

วิธีการได้มาซึ่งกลุ่มประชากรหรือผู้มีส่วนร่วมในการวิจัย

การประชาสัมพันธ์เพื่อรับสมัครอาสาสมัครเข้าร่วมการวิจัยผ่านทางผู้ประสานงานในแต่ละหน่วยฝึกทหารใหม่ จังหวัดกรุงเทพมหานคร โดยสามารถติดต่อเพื่อเข้าร่วมงานวิจัยได้ตามที่อยู่และเบอร์โทรศัพท์ของผู้วิจัยที่ระบุในเอกสารประชาสัมพันธ์

วิธีดำเนินการวิจัย

ท่านจะได้รับข้อมูลเกี่ยวกับการวิจัยโดยละเอียดจากเอกสาร “ข้อมูลสำหรับกลุ่มประชากรหรือผู้มีส่วนร่วมในการวิจัย” หากท่านมีข้อสงสัยเพิ่มเติม สามารถสอบถามผู้วิจัยได้โดยตรง หรือติดต่อตามหมายเลขโทรศัพท์ของผู้วิจัยที่ให้ไว้ข้างต้น โดยเมื่อท่านตกลงเข้าร่วมการศึกษา ผู้วิจัยจะขอนัดหมายวันและเวลาที่ท่านสะดวกเข้ารับการตรวจประเมิน เมื่อถึงวันนัดหมาย ขอให้ท่านใส่เสื้อกล้ามและกางเกงขาสั้นระดับเข่าที่ไม่รัดแน่นจนขยับตัวได้ลำบาก ผู้วิจัยจะขอให้ท่านลงนามในใบยินยอมเข้าร่วมวิจัย และตอบแบบสอบถาม 1 ฉบับจำนวน 5 หน้าเป็นเวลาทั้งสิ้น 5 นาที ประกอบด้วยการสอบถามข้อมูลทางด้านสุขภาพและการออกกำลัง ข้อมูลอาการปวดส้นเท้า ข้อมูลอาการปวดทางระบบกระดูกและกล้ามเนื้อส่วนหลังบั้นเอวและรยางค์ขา และข้อมูลทางด้านจิตใจ จากนั้นท่านจะได้รับการตรวจประเมินร่างกายโดย

นักกายภาพบำบัดประจำสถานี โดยใช้เวลา 5 นาทีต่อสถานี รวมเวลาที่ใช้ตรวจประเมินทั้งสิ้นประมาณ 35 นาทีต่อ 1 ท่าน ดังต่อไปนี้

สถานีที่ 1 ประกอบด้วย การประเมินความยืดหยุ่นของกล้ามเนื้อรอบสะโพก และการวัดความยาวขา

สถานีที่ 2 ประกอบด้วย การประเมินความแข็งแรงของกล้ามเนื้อสะโพก

สถานีที่ 3 ประกอบด้วย การประเมินโครงสร้างของข้อสะโพก โครงสร้างของกระดูกแข้ง และโครงสร้างของกระดูกนิ้วหัวแม่เท้า

สถานีที่ 4 ประกอบด้วย การประเมินโครงสร้างของกระดูกเชิงกราน โครงสร้างของข้อเข่า และคุณภาพการเคลื่อนไหวของลำตัวและรยางค์ขา

สถานีที่ 5 ประกอบด้วย การประเมินโครงสร้างของกระดูกสันหลัง ความยืดหยุ่นของกล้ามเนื้อน่อง และการเคลื่อนไหวของนิ้วหัวแม่เท้า

สถานีที่ 6 ประกอบด้วย การประเมินโครงสร้างของเท้า และความแข็งแรงของกล้ามเนื้อน่อง

สถานีที่ 7 ประกอบด้วย การประเมินโครงสร้างของอุ้งเท้า และการประเมินความพอดีของรองเท้าที่สวมใส่ในการฝึก

เมื่อครบ 12 สัปดาห์ ผู้วิจัยจะติดต่อท่านเพื่อนัดหมายวันและเวลาสำหรับการตรวจประเมินร่างกายเป็นครั้งที่ 2 โดยเมื่อถึงวันและเวลาที่นัดหมาย ทีมผู้วิจัยจะเข้าไปยังหน่วยงานของท่านอีกครั้ง เพื่อขอให้ท่านตอบแบบสอบถาม 1 ฉบับจำนวน 4 หน้าเป็นเวลาทั้งสิ้น 5 นาที และเข้ารับตรวจประเมินทางกายภาพบำบัดดังกล่าวอีกครั้ง โดยใช้เวลาตรวจประเมินทั้งสิ้นประมาณ 35 นาทีต่อ 1 ท่าน เมื่อสิ้นสุดการตรวจประเมินทั้ง 2 ครั้ง ผู้วิจัยจะนำข้อมูลข้างต้นมาวิเคราะห์และสรุปผลเป็นอันสิ้นสุดโครงการวิจัย

วิธีการให้ข้อมูลเกี่ยวกับโครงการวิจัยนี้แก่ท่าน

ผู้วิจัยจะให้ข้อมูลแก่ท่านโดยผ่านเอกสารฉบับนี้ และยินดีตอบคำถามของท่านทุกคำถามอย่างดีที่สุด ตลอดเวลา

ความเสี่ยงที่เกี่ยวข้องกับการศึกษาวิจัยนี้

การตรวจร่างกายที่ใช้ในการศึกษาวิจัยนี้ เป็นการตรวจประเมินทางกายภาพบำบัดทั่วไปที่ใช้โดยนักกายภาพบำบัดอยู่แล้ว อย่างไรก็ตาม ในระหว่างการตรวจประเมิน ท่านอาจมีความรู้สึกไม่สบายเฉพาะส่วนของร่างกายได้บ้าง แต่ความรู้สึกไม่สบายดังกล่าว โดยปกติจะหายไปในทันที หรือเกือบทันที เมื่อสิ้นสุดการตรวจประเมินนั้นๆ แล้ว

หากท่านได้รับการบาดเจ็บใดๆ หรืออาการทางระบบกระดูกและกล้ามเนื้อของท่านมีความรุนแรงมากขึ้น จากการเข้าร่วมการศึกษาวิจัยนี้ ทางคณะผู้ดำเนินการยินดีรับผิดชอบค่าใช้จ่ายในการรักษาพยาบาลที่เกิดขึ้นทั้งหมด

สิทธิของอาสาสมัคร

การเข้าร่วมในโครงการวิจัยนี้เป็นไปด้วยความสมัครใจ ท่านมีสิทธิ์ที่จะปฏิเสธที่จะเข้าร่วมหรือสามารถถอนตัวออกจากโครงการวิจัยในครั้งนี้ได้ทุกขณะ โดยไม่ต้องได้รับโทษ หรือสูญเสียประโยชน์และบริการรวมทั้งการดูแลรักษาที่พึงได้รับ โดยไม่จำเป็นต้องแจ้งเหตุผลของการถอดถอน และจะไม่มีภาระผูกพันใดๆต่อไปในอนาคต

หากท่านมีข้อสงสัยให้สอบถามเพิ่มเติมได้โดยสามารถติดต่อผู้วิจัยได้ตลอดเวลา และหากผู้วิจัยมีข้อมูลเพิ่มเติมที่เป็นประโยชน์หรือโทษเกี่ยวกับการวิจัย ผู้วิจัยจะแจ้งให้ท่านทราบอย่างรวดเร็วเพื่อให้ผู้มีส่วนร่วมในการวิจัยทบทวนว่ายังสมัครใจจะอยู่ในงานวิจัยต่อไปหรือไม่

ในการเข้าร่วมโครงการนี้ ท่านไม่ต้องเสียค่าใช้จ่ายใดๆ ทั้งสิ้น และทางคณะผู้วิจัยจะขอมอบ "แผ่นยางยืดสำหรับออกกำลังกาย" จำนวน 1 ชุด เป็นการตอบแทนที่ท่านได้กรุณาสละเวลาเข้าร่วมโครงการนี้ในวันที่สิ้นสุดโครงการวิจัย

ประโยชน์จากการเข้าร่วมโครงการศึกษาวิจัย

ในการเข้าร่วมการศึกษาวิจัยครั้งนี้ ท่านอาจไม่ได้รับประโยชน์ส่วนบุคคลใดๆ นอกจากการรับทราบผลการตรวจประเมินความเสี่ยงต่อการเกิดอาการปวดส้นเท้าของท่านจากผลการตรวจร่างกายทางกายภาพบำบัด

อย่างไรก็ตาม ประโยชน์ทางวิชาการต่อส่วนรวมที่จะเกิดขึ้นจากการเข้าร่วมการศึกษาวิจัยของท่านในครั้งนี้ ได้แก่ รูปแบบการตรวจประเมินความเสี่ยงต่อการเกิดอาการปวดส้นเท้า รวมไปถึงองค์ความรู้ทางด้านระบาดวิทยาหรือจำนวนผู้ที่มีความเสี่ยงต่อการเกิดอาการปวดส้นเท้าจากภาวะเอ็นรองฝ่าเท้าอักเสบ ซึ่งสามารถนำไปใช้เป็นแนวทางในการศึกษาเพื่อป้องกันและหาเทคนิคการรักษาทางกายภาพบำบัดที่มีประสิทธิภาพและช่วยลดอัตราการเกิดภาวะดังกล่าวจากโปรแกรมการฝึกพื้นฐานทางทหารในกลุ่มทหารเกณฑ์ชาวไทยต่อไป

การเปิดเผยข้อมูล

ข้อมูลส่วนตัวและข้อมูลอื่นๆ ที่อาจนำไปสู่การเปิดเผยตัวของท่าน จะได้รับการปกปิด ยกเว้นว่าได้รับคำยินยอมจากท่านหรือโดยกฎระเบียบและกฎหมายที่เกี่ยวข้องเท่านั้น ข้อมูลของท่านจะถูกเก็บไว้เป็นความลับเฉพาะคณะผู้วิจัย ผู้กำกับดูแลการวิจัย ผู้ตรวจสอบและคณะกรรมการพิจารณาจริยธรรม และจะเปิดเผยเฉพาะในรูปที่เป็นสรุปผลการวิจัย

“หากท่านมีข้อสงสัยให้สอบถามเพิ่มเติมได้ โดยสามารถติดต่อผู้วิจัยได้ตลอดเวลา และหากผู้วิจัยมีข้อมูลเพิ่มเติมที่เป็นประโยชน์หรือโทษเกี่ยวกับการวิจัย ผู้วิจัยจะแจ้งให้ท่านทราบอย่างรวดเร็ว”

หมายเหตุ หากท่านไม่ได้รับการปฏิบัติตามข้อมูลดังกล่าวสามารถร้องเรียนได้ที่ คณะกรรมการพิจารณาจริยธรรมการวิจัยในคน กลุ่มสหสถาบัน ชุดที่ 1 จุฬาลงกรณ์มหาวิทยาลัย 254 อาคารจามจุรี 1 ชั้น 2 ถนนพญาไท เขตปทุมวัน กรุงเทพฯ 10330 โทรศัพท์/โทรสาร 02-218-3202 **E-mail: eccu@chula.ac.th**

APPENDIX I

INFORMATION SHEET FOR STUDY 3

ข้อมูลสำหรับกลุ่มประชากรหรือผู้มีส่วนร่วมในการวิจัย

ชื่อโครงการวิจัย *ปัจจัยทางกายวิภาคศาสตร์และชีวกลศาสตร์ที่มีความสัมพันธ์กับภาวะเอ็นรองฝ่าเท้าอักเสบในกลุ่มทหารเกณฑ์เพศชายชาวไทย*

ผู้วิจัยหลัก นางสาวภาวิณี หฤทัยชื่น ตำแหน่ง นิสิตปริญญาเอก

สถานที่ติดต่อผู้วิจัย (นางสาวภาวิณี หฤทัยชื่น)
หน่วยงาน/สถาบัน ภาควิชากายภาพบำบัด คณะสหเวชศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
ที่อยู่ 492/34 ถนนสุขสวัสดิ์ เขตราษฎร์บูรณะ กรุงเทพฯ 10140
โทรศัพท์มือถือ 086-514-1564 E-mail: pavinee.h24@gmail.com

เรียน อาสาสมัครทุกท่าน

ท่านได้รับเชิญให้เป็นผู้มีส่วนร่วมในการวิจัยนี้ ก่อนที่ท่านจะตัดสินใจเข้าร่วมในการวิจัยนี้ มีความจำเป็นที่ท่านควรทำความเข้าใจว่า งานวิจัยนี้ทำเพราะเหตุใด และเกี่ยวข้องกับอะไร กรุณาใช้เวลาในการอ่านข้อมูลต่อไปนี้อย่างละเอียดรอบคอบ และสอบถามข้อมูลเพิ่มเติมหรือข้อมูลที่ไม่ชัดเจนได้ตลอดเวลา

โครงการนี้เกี่ยวข้องกับการวิจัยอะไร

โครงการวิจัยนี้เป็นการศึกษาเพื่อหาความแตกต่างของการเคลื่อนไหวบริเวณข้อสะโพก ข้อเข่า ข้อเท้า และข้อต่อภายในเท้าในขณะเดินระหว่างกลุ่มทหารเกณฑ์ที่มีและไม่มีอาการปวดส้นเท้าจากภาวะเอ็นรองฝ่าเท้าอักเสบ

สถานที่ดำเนินการวิจัย

ห้องปฏิบัติการการวิเคราะห์การเคลื่อนไหว ภาควิชากายภาพบำบัด คณะสหเวชศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย

รายละเอียดของกลุ่มประชากรหรือผู้มีส่วนร่วมในการวิจัย

โครงการวิจัยนี้ทำการศึกษาในอาสาสมัครจำนวนทั้งสิ้น 52 คน ซึ่งประกอบด้วยกลุ่มที่มีอาการปวดส้นเท้าและกลุ่มที่ไม่มีอาการปวดส้นเท้าจากภาวะเอ็นรองฝ่าเท้าอักเสบกลุ่มละ

26 คน โดยมีระยะเวลาในการดำเนินงานวิจัย 3 เดือน ท่านได้รับเชิญเข้าร่วมการวิจัยนี้ หากท่านมีคุณสมบัติดังนี้

- เป็นทหารเกณฑ์เพศชายชาวไทยที่เข้ารับการฝึกพื้นฐานทางทหารเป็นระยะเวลา 10 สัปดาห์ระหว่างเดือนพฤษภาคมถึงเดือนกรกฎาคมปี พ.ศ. 2559
- มีอายุระหว่าง 20-27 ปี
- *เป็นผู้ที่มีอาการปวดส้นเท้าด้านในขณะที่มีการลงน้ำหนัก โดยมีอาการปวดแบบตุบๆ ปวดแสบปวดร้อน หรือปวดแปลบขึ้นมาทันที โดยเฉพาะ 2-3 ก้าวแรกในตอนเช้าหลังตื่นนอน หรือหลังจากไม่ได้ลงน้ำหนักเป็นเวลานาน โดยอาการปวดจะค่อยๆ ดีขึ้นหลังจากการเดินไปประยะหนึ่ง แต่จะแย่ลงหากมีการเดิน ยืนติดต่อกันนาน การเดินเท้าเปล่า เดินบนปลายเท้า หรือเดินขึ้นบันได (กลุ่มที่มีอาการปวดส้นเท้า)*
- *ไม่มีอาการปวด ความรู้สึกที่ไม่สบาย หรือความรู้สึกที่ไม่ปกติ (เช่น ผิวหนังชา หรือขาอ่อนแรง เป็นต้น) ของหลังส่วนบั้นเอว สะโพก/ต้นขา เข่า น่อง/หน้าแข้ง ข้อเท้า/เท้า ภายในระยะเวลา 1 สัปดาห์ที่ผ่านมา (กลุ่มที่ไม่มีอาการปวดส้นเท้า)*
- ไม่เคยได้รับการผ่าตัดของกระดูกขามาก่อน
- ไม่เคยมีการหักของกระดูกขา
- ไม่มีปัญหาความผิดปกติของระบบในร่างกายจากการวินิจฉัยของแพทย์ เช่น การมีเนื้องอก หรือการติดเชื้อ ซึ่งอยู่ในระหว่างการรักษาจากแพทย์ผู้เชี่ยวชาญเฉพาะทาง
- ไม่ได้รับการวินิจฉัยจากแพทย์ว่ามีโรคดังต่อไปนี้ โรคเกาท์ หรือโรคมะเร็งกระดูก หรือโรคเบาหวานที่มีอาการชาเท้า หรือโรคกระดูกอักเสบ เช่น รูมาตอยด์
- ไม่มีอาการชาและอ่อนแรงที่ขา ไม่มีโครงสร้างของเท้าที่ผิดปกติ และมีความยาวขาเท่ากัน (จากการตรวจประเมินทางกายภาพบำบัดโดยผู้วิจัยหลัก)

วิธีการได้มาซึ่งกลุ่มประชากรหรือผู้มีส่วนร่วมในการวิจัย

การประชาสัมพันธ์เพื่อรับสมัครอาสาสมัครเข้าร่วมการวิจัยผ่านทางผู้ประสานงานในแต่ละหน่วยฝึกทหารใหม่ จังหวัดกรุงเทพมหานคร โดยสามารถติดต่อเพื่อเข้าร่วมงานวิจัยได้ตามที่อยู่และเบอร์โทรศัพท์ของผู้วิจัยที่ระบุในเอกสารประชาสัมพันธ์

วิธีดำเนินการวิจัย

ท่านจะได้รับข้อมูลเกี่ยวกับการวิจัยโดยละเอียดจากเอกสาร “ข้อมูลสำหรับกลุ่มประชากรหรือผู้มีส่วนร่วมในการวิจัย” หากท่านมีข้อสงสัยเพิ่มเติม สามารถสอบถามผู้วิจัยได้โดยตรง หรือติดต่อตามหมายเลขโทรศัพท์ของผู้วิจัยที่ให้ไว้ข้างต้น โดยเมื่อท่านตกลงเข้าร่วมการศึกษา ผู้วิจัยจะขอนัดหมายวันและเวลาที่ท่านสะดวกเข้ารับการตรวจประเมิน เมื่อถึงวัน

นัดหมาย ขอให้ท่านใส่เสื้อกล้ามและกางเกงขาสั้นระดับเข่าที่ไม่รัดแน่นจนขยับตัวได้ลำบาก จากนั้นจะขอให้ท่านลงนามในใบยินยอมเข้าร่วมวิจัย ก่อนเข้ารับการตรวจประเมินเพื่อวิเคราะห์การเคลื่อนไหวของข้อสะโพก ข้อเข่า ข้อเท้า และข้อต่อภายในเท้าในขณะเดินจากนักกายภาพบำบัด 2 คน ซึ่งประกอบด้วยผู้วิจัยหลัก ทำหน้าที่ระบุตำแหน่งของข้อต่อที่จะทำการตรวจประเมิน และนักกายภาพบำบัดอีก 1 คน ทำหน้าที่บันทึกภาพการเคลื่อนไหวของท่านทางคอมพิวเตอร์ในขณะเดินระยะทาง 10 เมตร จำนวน 10 รอบ โดยจะมีเวลาพักระหว่างรอบ 2 นาทีเพื่อป้องกันการล้าของกล้ามเนื้อ รวมเวลาในการตรวจประเมินทั้งสิ้นประมาณ 1 ชั่วโมงต่อ 1 ท่าน เมื่อสิ้นสุดการทดลองผู้วิจัยจะนำข้อมูลข้างต้นมาวิเคราะห์และสรุปผลเป็นอันสิ้นสุดโครงการวิจัย

วิธีการให้ข้อมูลเกี่ยวกับโครงการวิจัยนี้แก่ท่าน

ผู้วิจัยจะให้ข้อมูลแก่ท่านโดยผ่านเอกสารฉบับนี้ และยินดีตอบคำถามของท่านทุกคำถามอย่างดีที่สุด ตลอดเวลา

ความเสี่ยงที่เกี่ยวข้องกับการศึกษาวิจัยนี้

การตรวจร่างกายที่ใช้ในการศึกษาวิจัยนี้ เป็นการตรวจประเมินทางกายภาพบำบัดทั่วไปที่ใช้โดยนักกายภาพบำบัดอยู่แล้ว อย่างไรก็ตาม ในระหว่างการตรวจประเมิน ท่านอาจมีความรู้สึกไม่สบายเฉพาะส่วนของร่างกายได้บ้าง แต่ความรู้สึกไม่สบายดังกล่าว โดยปกติจะหายไปในทันที หรือเกือบทันที เมื่อสิ้นสุดการตรวจประเมินนั้นๆ แล้ว

หากท่านได้รับการบาดเจ็บใดๆ หรืออาการทางระบบกระดูกและกล้ามเนื้อของท่านมีความรุนแรงมากขึ้น จากการเข้าร่วมการศึกษาวิจัยนี้ ทางคณะผู้ดำเนินการยินดีรับผิดชอบค่าใช้จ่ายในการรักษาพยาบาลที่เกิดขึ้นทั้งหมด

สิทธิของอาสาสมัคร

การเข้าร่วมในโครงการวิจัยนี้เป็นไปด้วยความสมัครใจ ท่านมีสิทธิ์ที่จะปฏิเสธที่จะเข้าร่วมหรือสามารถถอนตัวออกจากโครงการวิจัยในครั้งนี้ได้ทุกขณะ โดยไม่ต้องได้รับโทษ หรือสูญเสียประโยชน์และบริการรวมทั้งการดูแลรักษาที่พึงได้รับ โดยไม่จำเป็นต้องแจ้งเหตุผลของการถอดถอน และจะไม่มีภาระผูกพันใดๆต่อไปในอนาคต

หากท่านมีข้อสงสัยให้สอบถามเพิ่มเติมได้โดยสามารถติดต่อผู้วิจัยได้ตลอดเวลา และหากผู้วิจัยมีข้อมูลเพิ่มเติมที่เป็นประโยชน์หรือโทษเกี่ยวกับการวิจัย ผู้วิจัยจะแจ้งให้ท่านทราบอย่างรวดเร็วเพื่อให้ผู้มีส่วนร่วมในการวิจัยทบทวนว่ายังสมัครใจจะอยู่ในงานวิจัยต่อไปหรือไม่

ในการเข้าร่วมโครงการนี้ ท่านไม่ต้องเสียค่าใช้จ่ายใดๆ ทั้งสิ้น และทางคณะผู้วิจัยจะขอมอบ "แผ่นยางยืดสำหรับออกกำลังกาย" จำนวน 1 ชุด เป็นการตอบแทนที่ท่านได้กรุณาสละเวลาเข้าร่วมโครงการนี้ในวันที่สิ้นสุดโครงการวิจัยในการศึกษาที่ 1

ท่านที่เข้าร่วมการศึกษาที่ 2 จะได้รับค่าพาหนะในการเดินทางมาพบผู้วิจัยคนละ 500 บาท และหนังสือกายภาพบำบัดสำหรับประชาชน คนละ 1 เล่ม สำหรับท่านที่มีอาการปวดส้นเท้าจากภาวะเอ็นรองฝ่าเท้าอักเสบจะได้รับโปรแกรมการรักษาเพิ่มเติมจากนักกายภาพบำบัด ซึ่งประกอบด้วย การติดเทป และการให้โปรแกรมการยืดกล้ามเนื้อเพื่อบรรเทาอาการปวด

ประโยชน์จากการเข้าร่วมโครงการศึกษาวิจัย

ในการเข้าร่วมการศึกษาวิจัยครั้งนี้ ท่านอาจไม่ได้รับประโยชน์ส่วนบุคคลใดๆ นอกจากการรับทราบผลการตรวจประเมินความเสี่ยงต่อการเกิดภาวะเอ็นรองฝ่าเท้าอักเสบของท่านจากผลการตรวจร่างกายทางกายภาพบำบัด

อย่างไรก็ตาม ประโยชน์ทางวิชาการต่อส่วนรวมที่จะเกิดขึ้นจากการเข้าร่วมการศึกษาวิจัยของท่านในครั้งนี้ ได้แก่ รูปแบบการตรวจประเมินความเสี่ยงต่อการเกิดภาวะเอ็นรองฝ่าเท้าอักเสบ รวมไปถึงองค์ความรู้ทางด้านระบาดวิทยาหรือจำนวนผู้ที่มีความเสี่ยงต่อการเกิดภาวะเอ็นรองฝ่าเท้าอักเสบ ซึ่งสามารถนำไปใช้เป็นแนวทางในการศึกษาเพื่อป้องกันและหาเทคนิคการรักษาทางกายภาพบำบัดที่มีประสิทธิภาพและช่วยลดอัตราการเกิดภาวะดังกล่าวจากโปรแกรมการฝึกพื้นฐานทางทหารในกลุ่มทหารเกณฑ์ชาวไทยต่อไป

การเปิดเผยข้อมูล

ข้อมูลส่วนตัวและข้อมูลอื่นๆ ที่อาจนำไปสู่การเปิดเผยตัวของท่าน จะได้รับการปกปิด ยกเว้นว่าได้รับคำยินยอมจากท่านหรือโดยกฎระเบียบและกฎหมายที่เกี่ยวข้องเท่านั้น ข้อมูลของท่านจะถูกเก็บไว้เป็นความลับเฉพาะคณะผู้วิจัย ผู้กำกับดูแลการวิจัย ผู้ตรวจสอบและคณะกรรมการพิจารณาจริยธรรม และจะเปิดเผยเฉพาะในรูปที่เป็นสรุปผลการวิจัย

"หากท่านมีข้อสงสัยให้สอบถามเพิ่มเติมได้ โดยสามารถติดต่อผู้วิจัยได้ตลอดเวลา และหากผู้วิจัยมีข้อมูลเพิ่มเติมที่เป็นประโยชน์หรือโทษเกี่ยวกับการวิจัย ผู้วิจัยจะแจ้งให้ท่านทราบอย่างรวดเร็ว"

หมายเหตุ หากท่านไม่ได้รับการปฏิบัติตามข้อมูลดังกล่าวสามารถร้องเรียนได้ที่
คณะกรรมการพิจารณาจริยธรรมการวิจัยในคน กลุ่มสหสถาบัน ชุดที่ 1 จุฬาลงกรณ์มหาวิทยาลัย 254 อาคารจามจุรี 1 ชั้น 2 ถนนพญาไท เขตปทุมวัน กรุงเทพฯ 10330
โทรศัพท์/โทรสาร 02-218-3202 **E-mail: eccu@chula.ac.th**

APPENDIX J
INFORMED CONSENT FOR STUDY 1 & 2

หนังสือแสดงความยินยอมเข้าร่วมการวิจัย

ทำที่..

วันที่............เดือน................พ.ศ............

เลขที่ ประชากรตัวอย่างหรือผู้มีส่วนร่วมในการวิจัย...............................

ข้าพเจ้า ซึ่งได้ลงนามท้ายหนังสือนี้ ขอแสดงความยินยอมเข้าร่วมโครงการวิจัย
ชื่อโครงการวิจัย ปัจจัยทางกายวิภาคศาสตร์และชีวกลศาสตร์ที่มีความสัมพันธ์กับภาวะเอ็นรองฝ่าเท้าอักเสบในกลุ่มทหารเกณฑ์เพศชายชาวไทย
ชื่อผู้วิจัย นางสาวภาวิณี หฤทัยชื่น
ที่อยู่ที่ติดต่อ ภาควิชากายภาพบำบัด คณะสหเวชศาสตร์ จุฬาฯ โทรศัพท์ 086-514-1564

ข้าพเจ้า **ได้รับทราบ**รายละเอียดเกี่ยวกับที่มาและวัตถุประสงค์ในการทำวิจัย รายละเอียดขั้นตอนต่างๆ ที่จะต้องปฏิบัติหรือได้รับการปฏิบัติ ความเสี่ยง/อันตราย และประโยชน์ซึ่งจะเกิดขึ้นจากการวิจัยเรื่องนี้ โดยได้อ่านรายละเอียดในเอกสารชี้แจงผู้เข้าร่วมการวิจัยโดยตลอด และ**ได้รับคำอธิบาย**จากผู้วิจัย **จนเข้าใจเป็นอย่างดี**แล้ว

ข้าพเจ้าจึง**สมัครใจ**เข้าร่วมในโครงการวิจัยนี้ ตามที่ระบุไว้ในเอกสารชี้แจงผู้เข้าร่วมการวิจัย โดยข้าพเจ้ายินยอมให้เก็บข้อมูล 2 ครั้ง โดยการเก็บข้อมูลแต่ละครั้ง ประกอบด้วย

- ตอบแบบสอบถามอาการบาดเจ็บทางระบบกระดูกและกล้ามเนื้อส่วนขา ใช้เวลาประมาณ 10 นาที

- รับการตรวจร่างกายจากนักกายภาพบำบัดซึ่งประกอบด้วย การประเมินโครงสร้างของกระดูกสันหลังและกระดูกเชิงกราน, ความแข็งแรงของกล้ามเนื้อสะโพก, ความยืดหยุ่นของกล้ามเนื้อสะโพก, คุณภาพการเคลื่อนไหวของลำตัวและรยางค์ขา, ความยาวขา, โครงสร้างของข้อสะโพก, โครงสร้างของข้อเข่า, โครงสร้างของกระดูกแข้ง, โครงสร้างของเท้า, ความแข็งแรงของกล้ามเนื้อน่อง, ความยืดหยุ่นของกล้ามเนื้อน่อง, การเคลื่อนไหวของนิ้วหัวแม่เท้า และการประเมินความพอดีของรองเท้าที่สวมใส่ในการฝึก ใช้เวลาประมาณ 40 นาที

ข้าพเจ้ามีสิทธิ**ถอนตัว**ออกจากการวิจัยเมื่อใดก็ได้ตามความประสงค์ **โดยไม่ต้องแจ้งเหตุผล** ซึ่งการถอนตัวออกจากการวิจัยนั้น จะไม่มีผลกระทบในทางใดๆ ต่อข้าพเจ้าทั้งสิ้น

ข้าพเจ้าได้รับคำรับรองว่า ผู้วิจัยจะปฏิบัติต่อข้าพเจ้าตามข้อมูลที่ระบุไว้ในเอกสารชี้แจงผู้เข้าร่วมการวิจัย และข้อมูลใดๆ ที่เกี่ยวข้องกับข้าพเจ้า ผู้วิจัยจะ**เก็บรักษาเป็นความลับ** โดยจะนำเสนอข้อมูลการวิจัยเป็นภาพรวมเท่านั้น ไม่มีข้อมูลใดในการรายงานที่จะนำไปสู่การระบุตัวข้าพเจ้า

หากข้าพเจ้าไม่ได้รับการปฏิบัติตรงตามที่ได้ระบุไว้ในเอกสารชี้แจงผู้เข้าร่วมการวิจัย ข้าพเจ้าสามารถร้องเรียนได้ที่คณะกรรมการพิจารณาจริยธรรมการวิจัยในคน กลุ่มสหสถาบัน ชุดที่ 1 จุฬาลงกรณ์มหาวิทยาลัย 254 อาคารจามจุรี 1 ชั้น 2 ถนนพญาไท เขตปทุมวัน กรุงเทพฯ 10330 โทรศัพท์/โทรสาร 0-2218-3202 **E-mail: eccu@chula.ac.th**

ข้าพเจ้าได้ลงลายมือชื่อไว้เป็นสำคัญต่อหน้าพยาน ทั้งนี้ข้าพเจ้าได้รับสำเนาเอกสารชี้แจงผู้เข้าร่วมการวิจัย และสำเนาหนังสือแสดงความยินยอมไว้แล้ว

ลงชื่อ...
(นางสาวภาวิณี หฤทัยชื่น)
ผู้วิจัยหลัก

ลงชื่อ..
(..)
ผู้มีส่วนร่วมในการวิจัย

ลงชื่อ...
(...)
พยาน

APPENDIX K
INFORMED CONSENT FOR STUDY 3

หนังสือแสดงความยินยอมเข้าร่วมการวิจัย

ทำที่...
วันที่............เดือน.....................พ.ศ. ....

เลขที่ ประชากรตัวอย่างหรือผู้มีส่วนร่วมในการวิจัย.........................

ข้าพเจ้า ซึ่งได้ลงนามท้ายหนังสือนี้ ขอแสดงความยินยอมเข้าร่วมโครงการวิจัย
ชื่อโครงการวิจัย ปัจจัยทางกายวิภาคศาสตร์และชีวกลศาสตร์ที่มีความสัมพันธ์กับภาวะเอ็นรองฝ่าเท้าอักเสบในกลุ่มทหารเกณฑ์เพศชายชาวไทย
ชื่อผู้วิจัย นางสาวภาวิณี หฤทัยชื่น
ที่อยู่ที่ติดต่อ ภาควิชากายภาพบำบัด คณะสหเวชศาสตร์ จุฬาฯ โทรศัพท์ 086-514-1564

ข้าพเจ้า **ได้รับทราบ**รายละเอียดเกี่ยวกับที่มาและวัตถุประสงค์ในการทำวิจัย รายละเอียดขั้นตอนต่างๆ ที่จะต้องปฏิบัติหรือได้รับการปฏิบัติ ความเสี่ยง/อันตราย และประโยชน์ซึ่งจะเกิดขึ้นจากการวิจัยเรื่องนี้ โดยได้อ่านรายละเอียดในเอกสารชี้แจงผู้เข้าร่วมการวิจัยโดยตลอด และ**ได้รับคำอธิบาย**จากผู้วิจัย **จนเข้าใจเป็นอย่างดี**แล้ว

ข้าพเจ้าจึง**สมัครใจ**เข้าร่วมในโครงการวิจัยนี้ ตามที่ระบุไว้ในเอกสารชี้แจงผู้เข้าร่วมการวิจัย โดยข้าพเจ้ายินยอมให้รับการคัดกรอง *เพื่อวิเคราะห์การเคลื่อนไหวของข้อต่อรยางค์ขาจากนักกายภาพบำบัด โดยใช้เวลาประมาณ 1 ชั่วโมง*

ข้าพเจ้ามีสิทธิ**ถอนตัว**ออกจากการวิจัยเมื่อใดก็ได้ตามความประสงค์ **โดยไม่ต้องแจ้งเหตุผล** ซึ่งการถอนตัวออกจากการวิจัยนั้น จะไม่มีผลกระทบในทางใดๆ ต่อข้าพเจ้าทั้งสิ้น

ข้าพเจ้าได้รับคำรับรองว่า ผู้วิจัยจะปฏิบัติต่อข้าพเจ้าตามข้อมูลที่ระบุไว้ในเอกสารชี้แจงผู้เข้าร่วมการวิจัย และข้อมูลใดๆ ที่เกี่ยวข้องกับข้าพเจ้า ผู้วิจัยจะ**เก็บรักษาเป็นความลับ** โดยจะนำเสนอข้อมูลการวิจัยเป็นภาพรวมเท่านั้น ไม่มีข้อมูลใดในการรายงานที่จะนำไปสู่การระบุตัวข้าพเจ้า

หากข้าพเจ้าไม่ได้รับการปฏิบัติตรงตามที่ได้ระบุไว้ในเอกสารชี้แจงผู้เข้าร่วมการวิจัย ข้าพเจ้าสามารถร้องเรียนได้ที่คณะกรรมการพิจารณาจริยธรรมการวิจัยในคน กลุ่มสหสถาบัน ชุดที่ 1 จุฬาลงกรณ์มหาวิทยาลัย 254 อาคารจามจุรี 1 ชั้น 2 ถนนพญาไท เขตปทุมวัน กรุงเทพฯ 10330 โทรศัพท์/โทรสาร 0-2218-3202 **E-mail: eccu@chula.ac.th**

ข้าพเจ้าได้ลงลายมือชื่อไว้เป็นสำคัญต่อหน้าพยาน ทั้งนี้ข้าพเจ้าได้รับสำเนาเอกสารชี้แจงผู้เข้าร่วมการวิจัย และสำเนาหนังสือแสดงความยินยอมไว้แล้ว

ลงชื่อ..
(นางสาวภาวิณี หฤทัยชื่น)
ผู้วิจัยหลัก

ลงชื่อ..
(..)
ผู้มีส่วนร่วมในการวิจัย

ลงชื่อ..
(..)
พยาน

REFERENCES

1. Riddle DL, Pulisic M, Pidcoe P, Johnson RE. Risk factors for Plantar fasciitis: a matched case-control study. The Journal of bone and joint surgery American volume. 2003;85-A(5):872-7.
2. McPoil TG, Martin RL, Cornwall MW, Wukich DK, Irrgang JJ, Godges JJ. Heel pain--plantar fasciitis: clinical practice guildelines linked to the international classification of function, disability, and health from the orthopaedic section of the American Physical Therapy Association. The Journal of orthopaedic and sports physical therapy. 2008;38(4):A1-A18.
3. Martin RL, Davenport TE, Reischl SF, McPoil TG, Matheson JW, Wukich DK, et al. Heel pain-plantar fasciitis: revision 2014. The Journal of orthopaedic and sports physical therapy. 2014;44(11):A1-33.
4. Goff JD, Crawford R. Diagnosis and treatment of plantar fasciitis. American family physician. 2011;84(6):676-82.
5. Cotchett MP, Whittaker G, Erbas B. Psychological variables associated with foot function and foot pain in patients with plantar heel pain. Clinical rheumatology. 2015;34(5):957-64.
6. Beeson P. Plantar fasciopathy: revisiting the risk factors. Foot and ankle surgery : official journal of the European Society of Foot and Ankle Surgeons. 2014;20(3):160-5.
7. Pujalte GG, Silvis ML. The injured runner. The Medical clinics of North America. 2014;98(4):851-68, xiii.
8. Taanila H, Suni JH, Kannus P, Pihlajamaki H, Ruohola JP, Viskari J, et al. Risk factors of acute and overuse musculoskeletal injuries among young

conscripts: a population-based cohort study. BMC musculoskeletal disorders. 2015;16:104.

9. Waclawski ER, Beach J, Milne A, Yacyshyn E, Dryden DM. Systematic review: plantar fasciitis and prolonged weight bearing. Occupational medicine. 2015;65(2):97-106.

10. Scher DL, Belmont PJ, Jr., Bear R, Mountcastle SB, Orr JD, Owens BD. The incidence of plantar fasciitis in the United States military. The Journal of bone and joint surgery American volume. 2009;91(12):2867-72.

11. Silanun K, Boontern, S. . Epidemiology of musculoskeletal and soft tissue injuries in Thai conscript basic training of the ninth infantry division. Royal Thai Army Medical Journal. 2012;65:11-9.

12. Krivickas LS. Anatomical factors associated with overuse sports injuries. Sports medicine. 1997;24(2):132-46.

13. Havenetidis K, Paxinos T. Risk factors for musculoskeletal injuries among Greek Army officer cadets undergoing Basic Combat Training. Military medicine. 2011;176(10):1111-6.

14. Rome K, Howe T, Haslock L. Risk factors associated with the development of plantar heel pain in athletes. The foot. 2002;11:119-25.

15. Irving DB, Cook JL, Menz HB. Factors associated with chronic plantar heel pain: a systematic review. Journal of science and medicine in sport. 2006;9(1-2):11-22; discussion 3-4.

16. Bolivar YA, Munuera PV, Padillo JP. Relationship between tightness of the posterior muscles of the lower limb and plantar fasciitis. Foot & ankle international. 2013;34(1):42-8.

17. Kibler WB, Goldberg C, Chandler TJ. Functional biomechanical deficits in running athletes with plantar fasciitis. The American journal of sports medicine. 1991;19(1):66-71.

18. Pohl MB, Hamill J, Davis IS. Biomechanical and anatomic factors associated with a history of plantar fasciitis in female runners. Clinical journal of sport medicine : official journal of the Canadian Academy of Sport Medicine. 2009;19(5):372-6.

19. Wearing SC, Smeathers JE, Urry SR. The effect of plantar fasciitis on vertical foot-ground reaction force. Clinical orthopaedics and related research. 2003(409):175-85.

20. Ribeiro AP, Trombini-Souza F, Tessutti V, Rodrigues Lima F, Sacco Ide C, Joao SM. Rearfoot alignment and medial longitudinal arch configurations of runners with symptoms and histories of plantar fasciitis. Clinics. 2011;66(6):1027-33.

21. Chang R, Rodrigues PA, Van Emmerik RE, Hamill J. Multi-segment foot kinematics and ground reaction forces during gait of individuals with plantar fasciitis. Journal of biomechanics. 2014;47(11):2571-7.

22. Cheng HY, Lin CL, Wang HW, Chou SW. Finite element analysis of plantar fascia under stretch-the relative contribution of windlass mechanism and Achilles tendon force. Journal of biomechanics. 2008;41(9):1937-44.

23. Wearing SC, Smeathers JE, Urry SR, Hennig EM, Hills AP. The pathomechanics of plantar fasciitis. Sports medicine. 2006;36(7):585-611.

24. Bolgla LA, Malone TR. Plantar fasciitis and the windlass mechanism: a biomechanical link to clinical practice. Journal of athletic training. 2004;39(1):77-82.

25. Sahrmann S. Diagnosis and treatment of movement impairment syndromes. St. Louis: Mosby; 2002.

26. Kulig K, Popovich JM, Jr., Noceti-Dewit LM, Reischl SF, Kim D. Women with posterior tibial tendon dysfunction have diminished ankle and hip muscle performance. The Journal of orthopaedic and sports physical therapy. 2011;41(9):687-94.

27. Bauer R. The effects of plantar fasciitis on multi-segment foot running gait kinematics. Master's Thesis in Kinesiology, University of Wisconsin-Milwaukee 2012.

28. Neely FG. Intrinsic risk factors for exercise-related lower limb injuries. Sports medicine. 1998;26(4):253-63.

29. Cagnie B, Danneels L, Van Tiggelen D, De Loose V, Cambier D. Individual and work related risk factors for neck pain among office workers: a cross sectional study. Eur Spine J. 2007;16(5):679-86.

30. Nahit ES, Hunt IM, Lunt M, Dunn G, Silman AJ, Macfarlane GJ. Effects of psychosocial and individual psychological factors on the onset of musculoskeletal pain: common and site-specific effects. Ann Rheum Dis. 2003;62(8):755-60.

31. van Tunen JA, Dell'Isola A, Juhl C, Dekker J, Steultjens M, Lund H. Biomechanical factors associated with the development of tibiofemoral knee

osteoarthritis: protocol for a systematic review and meta-analysis. BMJ Open. 2016;6(6):e011066.

32. Piva SR, Fitzgerald K, Irrgang JJ, Jones S, Hando BR, Browder DA, et al. Reliability of measures of impairments associated with patellofemoral pain syndrome. BMC musculoskeletal disorders. 2006;7:33.

33. Hedrick MR. The plantar aponeurosis. Foot & ankle international. 1996;17(10):646-9.

34. Hiramoto Y. Shape of the fibular part of the plantar aponeurosis in Japanese. Okajimas folia anatomica Japonica. 1983;60(5):329-37.

35. Cralley JC, Schuberth JM, Fitch KL. The deep band of the plantar aponeurosis of the human foot. Anatomischer Anzeiger. 1982;152(2):189-97.

36. Hicks JH. The mechanics of the foot. II. The plantar aponeurosis and the arch. Journal of anatomy. 1954;88(1):25-30.

37. Wright DG, Rennels DC. A Study of the Elastic Properties of Plantar Fascia. The Journal of bone and joint surgery American volume. 1964;46:482-92.

38. Thordarson DB, Schmotzer H, Chon J, Peters J. Dynamic support of the human longitudinal arch. A biomechanical evaluation. Clinical orthopaedics and related research. 1995(316):165-72.

39. Basmajian JV, Stecko G. The Role of Muscles in Arch Support of the Foot. The Journal of bone and joint surgery American volume. 1963;45:1184-90.

40. Di Caprio F, Buda R, Mosca M, Calabro A, Giannini S. Foot and lower limb diseases in runners: assessment of risk factors. Journal of sports science & medicine. 2010;9(4):587-96.

41. Kaufman KR, Brodine S, Shaffer R. Military training-related injuries: surveillance, research, and prevention. American journal of preventive medicine. 2000;18(3 Suppl):54-63.

42. Cosman F, Ruffing J, Zion M, Uhorchak J, Ralston S, Tendy S, et al. Determinants of stress fracture risk in United States Military Academy cadets. Bone. 2013;55(2):359-66.

43. Bonanno DR, Murley GS, Munteanu SE, Landorf KB, Menz HB. Foot orthoses for the prevention of lower limb overuse injuries in naval recruits: study protocol for a randomised controlled trial. Journal of foot and ankle research. 2015;8:51.

44. Roy TC. Diagnoses and mechanisms of musculoskeletal injuries in an infantry brigade combat team deployed to Afghanistan evaluated by the brigade physical therapist. Military medicine. 2011;176(8):903-8.

45. Werner RA, Gell N, Hartigan A, Wiggerman N, Keyserling WM. Risk factors for plantar fasciitis among assembly plant workers. PM & R : the journal of injury, function, and rehabilitation. 2010;2(2):110-6; quiz 1 p following 67.

46. Yi TI, Lee GE, Seo IS, Huh WS, Yoon TH, Kim BR. Clinical characteristics of the causes of plantar heel pain. Annals of rehabilitation medicine. 2011;35(4):507-13.

47. Birrell SA, Hooper RH, Haslam RA. The effect of military load carriage on ground reaction forces. Gait & posture. 2007;26(4):611-4.

48. Blacker SD, Wilkinson DM, Bilzon JL, Rayson MP. Risk factors for training injuries among British Army recruits. Military medicine. 2008;173(3):278-86.

49. Cavanagh PR, Lafortune MA. Ground reaction forces in distance running. Journal of biomechanics. 1980;13(5):397-406.

50. Franklyn-Miller A, Roberts A, Hulse D, Foster J. Biomechanical overload syndrome: defining a new diagnosis. British journal of sports medicine. 2014;48(6):415-6.

51. Taunton JE, Ryan MB, Clement DB, McKenzie DC, Lloyd-Smith DR, Zumbo BD. A retrospective case-control analysis of 2002 running injuries. British journal of sports medicine. 2002;36(2):95-101.

52. Irving DB, Cook JL, Young MA, Menz HB. Obesity and pronated foot type may increase the risk of chronic plantar heel pain: a matched case-control study. BMC musculoskeletal disorders. 2007;8:41.

53. Shaffer RA, Brodine SK, Ito SI, Le AT. Epidemiology of illness and injury among U.S. Navy and Marine Corps female training populations. Military medicine. 1999;164(1):17-21.

54. Shaffer RA, Brodine SK, Almeida SA, Williams KM, Ronaghy S. Use of simple measures of physical activity to predict stress fractures in young men undergoing a rigorous physical training program. American journal of epidemiology. 1999;149(3):236-42.

55. Rosendal L, Langberg H, Skov-Jensen A, Kjaer M. Incidence of injury and physical performance adaptations during military training. Clinical journal of sport medicine : official journal of the Canadian Academy of Sport Medicine. 2003;13(3):157-63.

56. Taanila H, Hemminki AJ, Suni JH, Pihlajamaki H, Parkkari J. Low physical fitness is a strong predictor of health problems among young men: a follow-up study of 1411 male conscripts. BMC public health. 2011;11:590.

57. Monaghan GM, Lewis CL, Hsu WH, Saltzman E, Hamill J, Holt KG. Forefoot angle determines duration and amplitude of pronation during walking. Gait & posture. 2013;38(1):8-13.

58. Alonso-Vazquez A, Villarroya MA, Franco MA, Asin J, Calvo B. Kinematic assessment of paediatric forefoot varus. Gait & posture. 2009;29(2):214-9.

59. Khamis S, Yizhar Z. Effect of feet hyperpronation on pelvic alignment in a standing position. Gait & posture. 2007;25(1):127-34.

60. Kendall JC, Bird AR, Azari MF. Foot posture, leg length discrepancy and low back pain--their relationship and clinical management using foot orthoses--an overview. Foot. 2014;24(2):75-80.

61. Barwick A, Smith J, Chuter V. The relationship between foot motion and lumbopelvic-hip function: a review of the literature. Foot. 2012;22(3):224-31.

62. Holt K HJ. Running injuries and treatment: a dynamic approach. St. Louis: Mosby: Rehabilitation of the foot and ankle. ; 1995.

63. Allen RH, Gross MT. Toe flexors strength and passive extension range of motion of the first metatarsophalangeal joint in individuals with plantar fasciitis. The Journal of orthopaedic and sports physical therapy. 2003;33(8):468-78.

64. Chang R, Kent-Braun JA, Hamill J. Use of MRI for volume estimation of tibialis posterior and plantar intrinsic foot muscles in healthy and chronic plantar fasciitis limbs. Clinical biomechanics. 2012;27(5):500-5.

65. Rathleff MS, Molgaard CM, Fredberg U, Kaalund S, Andersen KB, Jensen TT, et al. High-load strength training improves outcome in patients with plantar fasciitis: A randomized controlled trial with 12-month follow-up. Scandinavian journal of medicine & science in sports. 2015;25(3):e292-300.

66. Hopson MM, McPoil TG, Cornwall MW. Motion of the first metatarsophalangeal joint. Reliability and validity of four measurement techniques. Journal of the American Podiatric Medical Association. 1995;85(4):198-204.

67. Leetun DT, Ireland ML, Willson JD, Ballantyne BT, Davis IM. Core stability measures as risk factors for lower extremity injury in athletes. Medicine and science in sports and exercise. 2004;36(6):926-34.

68. Duval K, Lam T, Sanderson D. The mechanical relationship between the rearfoot, pelvis and low-back. Gait & posture. 2010;32(4):637-40.

69. Chuter VH, Janse de Jonge XA. Proximal and distal contributions to lower extremity injury: a review of the literature. Gait & posture. 2012;36(1):7-15.

70. Ireland ML, Willson JD, Ballantyne BT, Davis IM. Hip strength in females with and without patellofemoral pain. The Journal of orthopaedic and sports physical therapy. 2003;33(11):671-6.

71. Harty J, Soffe K, O'Toole G, Stephens MM. The role of hamstring tightness in plantar fasciitis. Foot & ankle international. 2005;26(12):1089-92.

72. Pinto RZ, Souza TR, Trede RG, Kirkwood RN, Figueiredo EM, Fonseca ST. Bilateral and unilateral increases in calcaneal eversion affect pelvic alignment in standing position. Manual therapy. 2008;13(6):513-9.

73. Labovitz JM, Yu J, Kim C. The role of hamstring tightness in plantar fasciitis. Foot & ankle specialist. 2011;4(3):141-4.

74. Shultz SJ, Nguyen AD, Windley TC, Kulas AS, Botic TL, Beynnon BD. Intratester and intertester reliability of clinical measures of lower extremity anatomic characteristics: implications for multicenter studies. Clinical journal of sport medicine : official journal of the Canadian Academy of Sport Medicine. 2006;16(2):155-61.

75. Mahmood S, Huffman LK, Harris JG. Limb-length discrepancy as a cause of plantar fasciitis. Journal of the American Podiatric Medical Association. 2010;100(6):452-5.

76. Portney LG, Watkins MP. Foundations of Clinical Research - Applications to Practice Edition r, editor. Upper Saddle River: Pearson Education Inc.; 2009.

77. Crowell RD, Cummings GS, Walker JR, Tillman LJ. Intratester and intertester reliability and validity of measures of innominate bone inclination. The Journal of orthopaedic and sports physical therapy. 1994;20(2):88-97.

78. Leard JS, Crane BA, Ball KA. Intrarater and interrater reliability of 22 clinical measures associated with lower quarter malalignment. Journal of manipulative and physiological therapeutics. 2009;32(4):270-6.

79. Herrington L. Assessment of the degree of pelvic tilt within a normal asymptomatic population. Manual therapy. 2011;16(6):646-8.

80. Badii M, Wade AN, Collins DR, Nicolaou S, Kobza BJ, Kopec JA. Comparison of lifts versus tape measure in determining leg length discrepancy. The Journal of rheumatology. 2014;41(8):1689-94.

81. Neelly K, Wallmann HW, Backus CJ. Validity of measuring leg length with a tape measure compared to a computed tomography scan. Physiotherapy theory and practice. 2013;29(6):487-92.

82. Gross MT, Burns CB, Chapman SW, Hudson CJ, Curtis HS, Lehmann JR, et al. Reliability and validity of rigid lift and pelvic leveling device method in assessing functional leg length inequality. The Journal of orthopaedic and sports physical therapy. 1998;27(4):285-94.

83. Neely FG. Biomechanical risk factors for exercise-related lower limb injuries. Sports medicine. 1998;26(6):395-413.

84. Souza RB, Powers CM. Concurrent criterion-related validity and reliability of a clinical test to measure femoral anteversion. The Journal of orthopaedic and sports physical therapy. 2009;39(8):586-92.

85. Kwon OY, Tuttle LJ, Commean PK, Mueller MJ. Reliability and validity of measures of hammer toe deformity angle and tibial torsion. Foot. 2009;19(3):149-55.

86. Jonson SR, Gross MT. Intraexaminer reliability, interexaminer reliability, and mean values for nine lower extremity skeletal measures in healthy naval midshipmen. The Journal of orthopaedic and sports physical therapy. 1997;25(4):253-63.

87. Buchanan KR, Davis I. The relationship between forefoot, midfoot, and rearfoot static alignment in pain-free individuals. The Journal of orthopaedic and sports physical therapy. 2005;35(9):559-66.

88. Otter SJ, Agalliu B, Baer N, Hales G, Harvey K, James K, et al. The reliability of a smartphone goniometer application compared with a traditional

goniometer for measuring first metatarsophalangeal joint dorsiflexion. Journal of foot and ankle research. 2015;8:30.

89. Lee KM, Ahn S, Chung CY, Sung KH, Park MS. Reliability and relationship of radiographic measurements in hallux valgus. Clinical orthopaedics and related research. 2012;470(9):2613-21.

90. Leardini A, Benedetti MG, Berti L, Bettinelli D, Nativo R, Giannini S. Rear-foot, mid-foot and fore-foot motion during the stance phase of gait. Gait & posture. 2007;25(3):453-62.

91. Wilken JM, Rodriguez KM, Brawner M, Darter BJ. Reliability and Minimal Detectible Change values for gait kinematics and kinetics in healthy adults. Gait & posture. 2012;35(2):301-7.

92. Yoho R, Rivera JJ, Renschler R, Vardaxis VG, Dikis J. A biomechanical analysis of the effects of low-Dye taping on arch deformation during gait. Foot. 2012;22(4):283-6.

93. Radford JA, Burns J, Buchbinder R, Landorf KB, Cook C. The effect of low-Dye taping on kinematic, kinetic, and electromyographic variables: a systematic review. The Journal of orthopaedic and sports physical therapy. 2006;36(4):232-41.

94. Park C, Lee S, Lim DY, Yi CW, Kim JH, Jeon C. Effects of the application of Low-Dye taping on the pain and stability of patients with plantar fasciitis. Journal of physical therapy science. 2015;27(8):2491-3.

95. van de Water AT, Speksnijder CM. Efficacy of taping for the treatment of plantar fasciosis: a systematic review of controlled trials. Journal of the American Podiatric Medical Association. 2010;100(1):41-51.

96. Landorf KB, Menz HB. Plantar heel pain and fasciitis. BMJ clinical evidence. 2008;2008.

97. Yamsri C, Pensri P. Effect of elastic therapeutic taping combined with stretching on heel pain and foot disability in persons with plantar fasciitis. . Master's Thesis, Department of physical therapy, Faculty of Allied Health Sciences, Chulalongkorn University 2012.

98. Owens BD, Wolf JM, Seelig AD, Jacobson IG, Boyko EJ, Smith B, et al. Risk Factors for Lower Extremity Tendinopathies in Military Personnel. Orthopaedic journal of sports medicine. 2013;1(1):2325967113492707.

99. Jones BH, Cowan DN, Knapik JJ. Exercise, training and injuries. Sports medicine. 1994;18(3):202-14.

100. van Leeuwen KD, Rogers J, Winzenberg T, van Middelkoop M. Higher body mass index is associated with plantar fasciopathy/'plantar fasciitis': systematic review and meta-analysis of various clinical and imaging risk factors. British journal of sports medicine. 2016;50(16):972-81.

101. Kamonseki DH, Goncalves GA, Yi LC, Junior IL. Effect of stretching with and without muscle strengthening exercises for the foot and hip in patients with plantar fasciitis: A randomized controlled single-blind clinical trial. Manual therapy. 2016;23:76-82.

102. Steinberg N, Dar G, Dunlop M, Gaida JE. The relationship of hip muscle performance to leg, ankle and foot injuries: a systematic review. The Physician and sportsmedicine. 2017;45(1):49-63.

103. Nguyen AD, Boling MC, Slye CA, Hartley EM, Parisi GL. Various methods for assessing static lower extremity alignment: implications for prospective risk-factor screenings. Journal of athletic training. 2013;48(2):248-57.

104. Azevedo LB, Lambert MI, Vaughan CL, O'Connor CM, Schwellnus MP. Biomechanical variables associated with Achilles tendinopathy in runners. British journal of sports medicine. 2009;43(4):288-92.

105. Coppieters MW, Alshami AM, Babri AS, Souvlis T, Kippers V, Hodges PW. Strain and excursion of the sciatic, tibial, and plantar nerves during a modified straight leg raising test. Journal of orthopaedic research : official publication of the Orthopaedic Research Society. 2006;24(9):1883-9.

106. Brown TA, Chorpita BF, Korotitsch W, Barlow DH. Psychometric properties of the Depression Anxiety Stress Scales (DASS) in clinical samples. Behaviour research and therapy. 1997;35(1):79-89.

107. Oei TP, Sawang S, Goh YW, Mukhtar F. Using the Depression Anxiety Stress Scale 21 (DASS-21) across cultures. Int J Psychol. 2013;48(6):1018-29.

108. Baecke JA, Burema J, Frijters JE. A short questionnaire for the measurement of habitual physical activity in epidemiological studies. The American journal of clinical nutrition. 1982;36(5):936-42.

109. Kuorinka I, Jonsson B, Kilbom A, Vinterberg H, Biering-Sorensen F, Andersson G, et al. Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. Applied ergonomics. 1987;18(3):233-7.

110. Rabin A, Kozol Z, Finestone AS. Limited ankle dorsiflexion increases the risk for mid-portion Achilles tendinopathy in infantry recruits: a prospective cohort study. Journal of foot and ankle research. 2014;7(1):48.

111. Abramoff MD, Magalhaes PJ, Ram SJ. Image processing with ImageJ. Biophotonics international. 2004;11(7):36-42.

112. Magee D. Orthopaedic Physical Assessment. . 2nd ed. Philadelphia, PA: W.B. Saunders Company; 1992.

113. Devan MR, Pescatello LS, Faghri P, Anderson J. A Prospective Study of Overuse Knee Injuries Among Female Athletes With Muscle Imbalances and Structural Abnormalities. Journal of athletic training. 2004;39(3):263-7.

114. Lunsford BR, Perry J. The standing heel-rise test for ankle plantar flexion: criterion for normal. Physical therapy. 1995;75(8):694-8.

115. Hosmer DW, Lemeshow S. Applied Logistic Regression. 2nd ed. New York: Wiley Chicago; 2000.

116. Sullivan E, Hudson J. The Cure That Lies Within: The Mind-Body Connection in Orthopaedics. Orthopedic nursing. 2017;36(2):153-8.

117. Vlaeyen JW, Linton SJ. Fear-avoidance and its consequences in chronic musculoskeletal pain: a state of the art. Pain. 2000;85(3):317-32.

118. Wilson VanVoorhis CR, Morgan BL. Understanding power and rules of thumb for determining sample sizes. Tut Quant Meth Psychol. 2007;3:43-50.

119. Santos BD, Correa LA, Teixeira Santos L, Filho NA, Lemos T, Nogueira LA. Combination of Hip Strengthening and Manipulative Therapy for the Treatment of Plantar Fasciitis: A Case Report. Journal of chiropractic medicine. 2016;15(4):310-3.

120. Salvioli S, Guidi M, Marcotulli G. The effectiveness of conservative, non-pharmacological treatment, of plantar heel pain: A systematic review with meta-analysis. Foot. 2017;33:57-67.

121. Kleinbaum DG, Kupper LL, Muller KE, et a. Applied regression analysis and other multivariable methods. 3rd ed. Pacific Grove: Duxbury Press; 1998.

122. Riddle DL, Pulisic M, Sparrow K. Impact of demographic and impairment-related variables on disability associated with plantar fasciitis. Foot & ankle international. 2004;25(5):311-7.

123. Ozcan Kahraman B, Salik Sengul Y, Kahraman T, Kalemci O. Developing a Reliable Core Stability Assessment Battery for Patients with Nonspecific Low Back Pain. Spine. 2016;41(14):E844-50.

124. Rabin A, Kozol Z, Moran U, Efergan A, Geffen Y, Finestone AS. Factors associated with visually assessed quality of movement during a lateral step-down test among individuals with patellofemoral pain. The Journal of orthopaedic and sports physical therapy. 2014;44(12):937-46.

125. Jacobs MS. Psychological Factors Influencing Chronic Pain and the Impact of Litigation. Curr Phys Med Rehabil Rep. 2013;1(2):135-41.

126. Cotchett M, Lennecke A, Medica VG, Whittaker GA, Bonanno DR. The association between pain catastrophising and kinesiophobia with pain and function in people with plantar heel pain. Foot. 2017;32:8-14.

127. Sullivan MJ, Thorn B, Haythornthwaite JA, Keefe F, Martin M, Bradley LA, et al. Theoretical perspectives on the relation between catastrophizing and pain. The Clinical journal of pain. 2001;17(1):52-64.

128. Kwong PK, Kay D, Voner RT, White MW. Plantar fasciitis. Mechanics and pathomechanics of treatment. Clinics in sports medicine. 1988;7(1):119-26.

129. Harutaichun P, Pensri P, Boonyong S. Predictors of plantar fasciitis in Thai novice conscripts after 10-week military training: A prospective study. In press 2018.

130. Nigg BM. The role of impact forces and foot pronation: a new paradigm. Clinical journal of sport medicine : official journal of the Canadian Academy of Sport Medicine. 2001;11(1):2-9.

131. Nigg BM. Biomechanics, load analysis and sports injuries in the lower extremities. Sports medicine. 1985;2(5):367-79.

132. Williams DS, 3rd, McClay IS, Hamill J. Arch structure and injury patterns in runners. Clinical biomechanics. 2001;16(4):341-7.

133. Bejarano T, Bhatia D, Brunt D, Jung R. Analysis of Neuromuscular Control in Young and Older Individuals During Lateral Stepping2013. 67-8 p.

134. Kadaba MP, Ramakrishnan HK, Wootten ME. Measurement of lower extremity kinematics during level walking. Journal of orthopaedic research : official publication of the Orthopaedic Research Society. 1990;8(3):383-92.

135. De Cock A, De Clercq D, Willems T, Witvrouw E. Temporal characteristics of foot roll-over during barefoot jogging: reference data for young adults. Gait & posture. 2005;21(4):432-9.

136. Neumann DA. Kinesiology of the musculoskeletal system: Foundations for rehabilitation. 2nd ed. United States: Mosby, Elsevier; 2010.

137. Perry J. Gait Analysis of Normal and Pathological Function. United States: Slack Inc; 1992.

138. Lee SY, Hertel J, Lee SC. Rearfoot eversion has indirect effects on plantar fascia tension by changing the amount of arch collapse. Foot. 2010;20(2-3):64-70.

139. Hudson D. The rotational profile: A study of lower limb axial torsion, hip rotation, and the foot progression angle in healthy adults. Gait & posture. 2016;49:426-30.

140. McDonald KA, Stearne SM, Alderson JA, North I, Pires NJ, Rubenson J. The Role of Arch Compression and Metatarsophalangeal Joint Dynamics in Modulating Plantar Fascia Strain in Running. PloS one. 2016;11(4):e0152602.

141. Caravaggi P, Pataky T, Gunther M, Savage R, Crompton R. Dynamics of longitudinal arch support in relation to walking speed: contribution of the plantar aponeurosis. Journal of anatomy. 2010;217(3):254-61.

142. McPoil TG, Knecht HG. Biomechanics of the foot in walking: a function approach. The Journal of orthopaedic and sports physical therapy. 1985;7(2):69-72.

143. Grabiner MD, Koh TJ, Draganich LF. Neuromechanics of the patellofemoral joint. Medicine and science in sports and exercise. 1994;26(1):10-21.

144. Simpson KJ, Jiang P. Foot landing position during gait influences ground reaction forces. Clinical biomechanics. 1999;14(6):396-402.

145. Lee P, Liu CH, Fan CW, Lu CP, Lu WS, Hsieh CL. The test-retest reliability and the minimal detectable change of the Purdue pegboard test in schizophrenia. Journal of the Formosan Medical Association = Taiwan yi zhi. 2013;112(6):332-7.

VITA

Pavinee Harutaichun was born on July 24, 1987 in Bangkok, Thailand. She graduated a Bachelor degree in Physical Therapy from the Faculty of Allied Health Sciences, Chulalongkorn University in 2009. Since she graduated, she has worked as physical therapist at Health Sciences service unit (HSSU), Faculty of Allied Health Sciences, Chulalongkorn University until now. In 2013, she graduated a Master degree in Public health from College of Public Health Sciences, Chulalongkorn University. Then she continued studying in a Doctoral degree of Physical Therapy at Faculty of Allied Health Sciences, Chulalongkorn University.